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# Ornamental Plants - - 1984: A Summary of Research

The Ohio State University
Ohio Agricultural Research and Development Center
Wooster, Ohio

# CONTENTS

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**ON THE COVER:** Elaine Toth (left), undergraduate student, and Sharon Treaster, research technician, measure growth of woody landscape plants produced on capillary sand beds. This study is part of a larger project designed to evaluate the effects of capillary watering to reduce the need for overhead watering and higher water consumption and to reduce excess water runoff.



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# Fertilizing Trees in the Landscape: A 12-Year Evaluation

ELTON M. SMITH AND SHARON A. TREASTER[1]

## ABSTRACT

Significant caliper growth increases of *Tilia* were recorded from drill hole treatments, without fertilizer, indicating a direct benefit from aeration in poorly drained soil. All fertilizer treatments of *Tilia* resulted in trunk caliper increases but there were no differences between rates of application. The most caliper growth of *Malus* was observed in the 6 and 9 lb N treatments. The 6 lb N drill hole and 9 lb N surface treatments resulted in significantly larger caliper than control trees of *Acer*. After 12 years, growth of *Tilia cordata, Malus* 'Snowdrift', and *Acer saccharum* 'Monumentale' was not affected by fertilizer placement.

## INTRODUCTION

The majority of trees planted around newly constructed residences and commercial buildings are located in soils which are less than desirable for plant growth. These sites are often composed of subsoils which are typically low in organic matter, heavily compacted, and poorly drained. For these reasons, trees in the landscape must be fertilized regularly to survive when planted in poor soils. A well-fertilized tree will generally be more resistant to insect and disease problems and more tolerant of winter conditions.

Fertilizer recommendations for trees historically have been based on trunk caliper. In recent literature, however, the basis has changed to soil surface area (1, 3, 4). Nutrition research and subsequent recommendations indicate that optimum tree growth will result from the application of from 2-3 lb N/1000 sq ft/yr to 6 lb N/1000 sq ft (5, 6, 9, 10, 11). Tree growth appears to be more directly related to fertilizer rate than to differences in fertilizer placement (2, 7).

The objectives of this research were to evaluate tree growth, in sites similar to many home landscapes, as a function of four nitrogen levels and two placement methods.

## MATERIALS AND METHODS

Branched whips of *Tilia cordata* 'Select' — Improved Littleleaf Linden, *Malus* 'Snowdrift' — Snowdrift Flowering Crabapple, and *Acer saccharum* 'Monumentale' —Sentry Sugar Maple were planted in April 1969. The trees were grown in sod culture and the turf mowed as needed. There were 12 trees per fertilizer treatment/species.

All trees received 6 lb of actual phosphorus and potassium per 1000 sq ft in May 1971 and in April of 1974, 1977, and 1980. The nitrogen, in the form of ammonium nitrate, was applied at the same time at either 0, 3, 6, or 9 lb N/1000 sq ft. One-half of the treated trees received nitrogen as a surface application while the remainder were treated via a drill hole application. The 20 holes per tree, drilled with a 2-inch power auger to a 12-inch depth, were spaced in two concentric rings in a 100 sq ft area around each tree. In the drill hole treatments, the fertilizer was mixed with calcined clay marketed as Sta-red-bits. One treatment consisted of a drill hole treatment filled with calcined clay without fertilizer to evaluate the effects from aeration alone.

This investigation was conducted at the USDA Nursery Crops Research Nursery in Delaware, Ohio. The soils were poorly drained Blount and Morley silt and Pewamo silty clay loam with a pH of 6.9.

The study was conducted utilizing a randomized block design with three trees per treatment and four replications. The data were analyzed by ANOVA using Duncan's Multiple Range Test at the 5% level of significance for mean separation.

## RESULTS AND DISCUSSION

Providing aeration to the root system has been recommended as a means of improving tree growth. This was observed in this study with *Tilia* after 12 years, with *Malus* after only 6 years, and not with *Acer* (Tables 1-3).

All treatments resulted in significant growth increases of *Tilia* when compared to the control trees which received no nitrogen (Table 1). However, there were no significant differences after 12 years between 3, 6, or 9 lb N/1000 sq ft treatments or between drill hole or surface placements. Average caliper growth of *Tilia* was larger than either *Malus* or *Acer*. Trunk splitting of control trees observed in 1974 (8), most likely the result of stress from nitrogen deficiency and excess soil moisture, was still evident on many trees in 1983.

The stimulation of caliper growth of *Malus* was pronounced from fertilizer treatments after 3 and 6 years but not after 9 or 12 years (Table 2). However, trees in 6 lb N surface and 9 lb N drill hole treatments were significantly larger than control trees.

In general, the average caliper growth of Sentry Sugar Maple was less than either of the other two species. The 3 and 6 lb N drill hole and 9 lb N surface treatments were significantly larger in caliper than control trees after 12 years. Similar differences were found after 9 years.

There were no consistent growth differences in any of the genera between drill hole and surface treatments.

The diameter of branch spread as a result of fertilizer treatments was as indicative of growth differences as caliper growth (Table 4). Again, little differences in diameter of branch spread were evident between fertilizer placement treatments.

The branch spreads of all *Tilia* were larger than control trees. The branch spreads of all *Acer* except drill holes only and 3.0 lb N surface treatments were larger than control trees. Only the 9 lb N drill hole and 6 and 9 lb N surface *Malus* were larger than control trees.

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Table 1. Average caliper growth in inches of Littleleaf Linden after 3, 6, 9 and 12 years of nitrogen fertilizer treatment.

| Treatment | 3 Years | 6 Years | 9 Years | 12 Years | Av./yr |
|---|---|---|---|---|---|
| Control, No Holes, No N | 2.0* | 3.03 a** | 4.84b | 7.10b | 0.59 |
| Holes Only plus Calcined Clay | 2.9 | 4.33b | 6.38a | 8.73a | 0.73 |
| 3 lb N Drill Hole | 3.0 | 4.58bc | 6.71a | 8.73a | 0.73 |
| 6 lb N Drill Hole | 3.0 | 4.55bc | 6.83a | 9.14a | 0.76 |
| 9 lb N Drill Hole | 3.0 | 4.80cd | 7.03a | 8.98a | 0.75 |
| 3 lb N Surface | 3.0 | 4.78bcd | 6.90a | 9.33a | 0.78 |
| 6 lb N Surface | 3.2 | 4.90cd | 6.88a | 9.09a | 0.76 |
| 9 lb N Surface | 3.1 | 5.08d | 7.49a | 9.93a | 0.83 |

*Each figure represents the average of 12 trees measured 1 foot from the soil line.

**Letters followed by dissimilar letters within columns are significantly different at the 5% level.

Table 2. Average caliper growth in inches of Snowdrift Flowering Crabapple after 3, 6, 9 and 12 years of nitrogen fertilizer treatment.

| Treatment | 3 Years | 6 Years | 9 Years | 12 Years | Av./yr |
|---|---|---|---|---|---|
| Control, No Holes, No N | 2.7* | 3.40a** | 5.19c | 6.35cd | 0.53 |
| Holes Only plus Calcined Clay | 3.0 | 4.30b | 5.53abc | 6.21d | 0.52 |
| 3 lb N Drill Hole | 2.8 | 4.35b | 5.28bc | 6.68bcd | 0.56 |
| 6 lb N Drill Hole | 3.1 | 4.83cd | 6.23ab | 6.88abcd | 0.57 |
| 9 lb N Drill Hole | 3.1 | 4.85cd | 6.23ab | 7.90a | 0.66 |
| 3 lb N Surface | 2.8 | 4.50bc | 5.40abc | 6.78bcd | 0.57 |
| 6 lb N Surface | 3.3 | 5.13d | 6.39a | 7.74ab | 0.64 |
| 9 lb N Surface | 3.1 | 4.85cd | 6.17ab | 7.43abc | 0.62 |

* Each figure represents the average of 12 trees measured 1 foot from the soil line.

** Letters followed by dissimilar letters within columns are significantly different at the 5% level.

Table 3. Average caliper growth in inches of Sentry Maple after 3, 6, 9 and 12 years of nitrogen fertilizer treatment.

| Treatment | 3 Years | 6 Years | 9 Years | 12 Years | Av./yr |
|---|---|---|---|---|---|
| Control, No Holes, No N | 2.5* | 3.38a** | 4.71bc | 5.87c | 0.49 |
| Holes only plus Calcined Clay | 2.8 | 3.50ab | 4.56c | 5.90c | 0.49 |
| 3 lb N Drill Hole | 2.9 | 4.00cd | 5.46abc | 7.15ab | 0.60 |
| 6 lb N Drill Hole | 3.2 | 4.50e | 6.11a | 7.64a | 0.64 |
| 9 lb N Drill Hole | 2.9 | 3.95bcd | 5.50ab | 6.99abc | 0.58 |
| 3 lb N Surface | 2.8 | 3.53ab | 4.93bc | 6.23bc | 0.52 |
| 6 lb N Surface | 2.9 | 3.88bc | 5.36abc | 6.88abc | 0.57 |
| 9 lb N Surface | 3.1 | 4.35cd | 5.98a | 7.50a | 0.63 |

* Each figure represents the average of 12 trees measured 1 foot from the soil line.

** Letters followed by dissimilar letters within columns are significantly different at the 5% level.

Table 4. Diameter of branch spread following 12 years of nitrogen fertilizer.

| Treatment | Littleleaf Linden | Snowdrift Flowering Crabapple | Sentry Sugar Maple |
|---|---|---|---|
| | | (Diameter in Feet) | |
| Control, No Holes, No N | 13.5*c | 16.1c** | 14.0b |
| Holes only | 17.5b | 16.4bc | 13.9b |
| 3 lb. N Drill Hole | 17.5b | 16.5bc | 18.0a |
| 6 lb. N Drill Hole | 18.6ab | 17.3abc | 18.3a |
| 9 lb. N Drill Hole | 19.3ab | 19.0a | 17.7a |
| 3 lb. N Surface | 18.6ab | 16.6bc | 16.5ab |
| 6 lb. N Surface | 18.9ab | 18.6ab | 17.5a |
| 9 lb. N Surface | 20.6a | 18.7ab | 18.6a |

* Each figure represents an average of 12 trees.

** Letters followed by dissimilar letters within columns are significantly different at the 5% level.

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# Effects of Rate and Timing of Fertilizer Application on Growth of Four Woody Species[1]

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## ABSTRACT

A 20-4-8 fertilizer (0.8% ammoniacal N, 12.5% urea N, and 6.7% water soluble N), varying in rate and time of application, was applied to *Viburnum plicatum* var. *tomentosum*, *Spiraea nipponica* 'Snowmound', *Juniperus chinensis* 'Hetzii Glauca', and *Taxus media* 'Sebian'. Fertilizer application once a year in October or June was as effective as split applications at various times.

## INTRODUCTION

Several factors influence the fertilization program utilized for landscape plants. There are recommendations for amounts of fertilizer to apply and also broad recommendations for frequency and timing. However, recommendations for timing are general and have not been justified in terms of scientific research. Some references suggest that split applications in fall and spring should be utilized (4). Others suggest applications in the fall, while still others recommend early spring applications (1).

A rate of 3-6 lb N/1000 sq ft is recommended for deciduous shrubs and narrowleaf evergreens (4). Landscape maintenance firms would be interested in a one-time fertilizer application in the fall which would spread their work load throughout the year. Producers of fertilizers would also like to promote the use of fertilizer in the fall as well as in the spring.

The intent of this study was to determine if split fertilizer applications were more beneficial for plant growth than one-time applications in fall or spring. A fall tolerance level of 2x fertilizer rate was also included in the study.

## MATERIALS AND METHODS

One gallon size plants of *Viburnum plicatum* var. *tomentosum*, *Spiraea nipponica* 'Snowmound', *Juniperus chinensis* 'Hetzii Glauca', and 1 quart size *Taxus media* 'Sebian' were planted in July 1979 at the Horticulture Research Farm, OSU, Columbus, Ohio. A 20-4-8 (0.8% ammoniacal N, 12.5% urea N, and 6.7% water soluble N) fertilizer was banded 9" on each side of the plants according to the treatments listed in Table 1. Plant height of *Viburnum*, *Spiraea*, and *Juniperus* and dry weight of *Taxus* were recorded in October 1981. A plant growth index was determined by adding the height and width of each plant and dividing by two. Tissue samples of shoots or leaves were used to determine tissue N by a modified micro-Kjeldahl method. The plants were grown under nursery conditions in a randomized complete block design with four replications of five plants each. Treatment means were analyzed by LSD at the 5% level.

## RESULTS AND DISCUSSION

Mean plant growth or dry weight within species was comparable across all nine treatments. Plants in Figure 1 and data of Table 2 indicate that growth differences were minimal among plant treatments.

With the exception of *Taxus*, no definite trend could be identified. However, dry weight data of *Taxus* (Table 2) indicate that the plants responded with greater growth when fertilized with a split application. The four lowest treatments in this species were 4 or 8 lb applications, which were applied once during the year. This trend with *Taxus* is due to its pattern of growth which occurs in flushes or spurts. These flushes are dependent on nutrients stored after the first flush (2). The second or third application, which was applied at about the time the first flush was finished, accounted for a vigorous second growth flush.

The other three species do not exhibit these dominant growth spurts. Consequently, the timing of fertilizer application did not affect growth in the same manner as that of *Taxus*.

Leaf tissue analysis of N was also similar among treatments with the exception of *Viburnum* (Table 3). The three plant treatments with the highest percent N were those that received fertilizer in June. Visual observation on July 17 found that the plants fertilized once, whether fall or spring, were slightly yellower than those plants receiving split applications. Also, the plants receiving a 4 lb rate applied in three applications in October, May, and June were paler than plants receiving 6 lb over the same three periods. This is reflected in Table 3, which indicates a significant difference between treatment 9 and treatment 8. Even though there were apparent visual foliage color differences, there were no significant differences in height.

There were significant differences in percent N in the tissue among the four species (Table 4). The *Viburnum* species had the lowest average percent N (1.74), which was significantly lower than the others. Although this value was not in the deficient range, it was on the low side (4) and indicates that *Viburnum* is a species which requires a high amount of nitrogen.

The 2x tolerance level of 8 lb N/1000 sq ft had no deleterious effect on plant growth (Table 2). There was no damage to the leaves or stems. The plant growth or dry weight of this treatment was low in three or four species, but the differences were not significant. Although no significant injury occurred, it is obvious that this rate would not result in optimum growth.

[1]Supported in part by funds from O. M. Scott and Sons, Marysville, Ohio.

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Table 1. A 20-4-8 fertilizer was applied each year at the following times and rates to Viburnum plicatum var. tomentosum; Spiraea nipponica 'Snowmound'; Juniperus chinensis 'Hetzii Glauca'; and Taxus media 'Sebian'. Fertilization started in October, 1979 and ended in October, 1981.

| Treatment | Single Application Rates lbs N/1000 ft$^2$ | Yearly Rates lbs N/1000 ft$^2$ | Application Date |
|---|---|---|---|
| 1 | 4.0 | 4 | October 15 |
| 2 | 4.0 | 4 | March 15 |
| 3 | 4.0 | 4 | June 15 |
| 4 | 8.0 | 8 | October 15 |
| 5 | 2.0 | 4 | October 15 |
| | 2.0 | | March 15 |
| 6 | 2.0 | 4 | March 15 |
| | 2.0 | | June 15 |
| 7 | 2.0 | 4 | October 15 |
| | 2.0 | | June 15 |
| 8 | 1.33 | | October 15 |
| | 1.33 | 4 | March 15 |
| | 1.33 | | June 15 |
| 9 | 2.0 | | October 15 |
| | 2.0 | 6 | March 15 |
| | 2.0 | | June 15 |
| 10 | Control | 0 | |

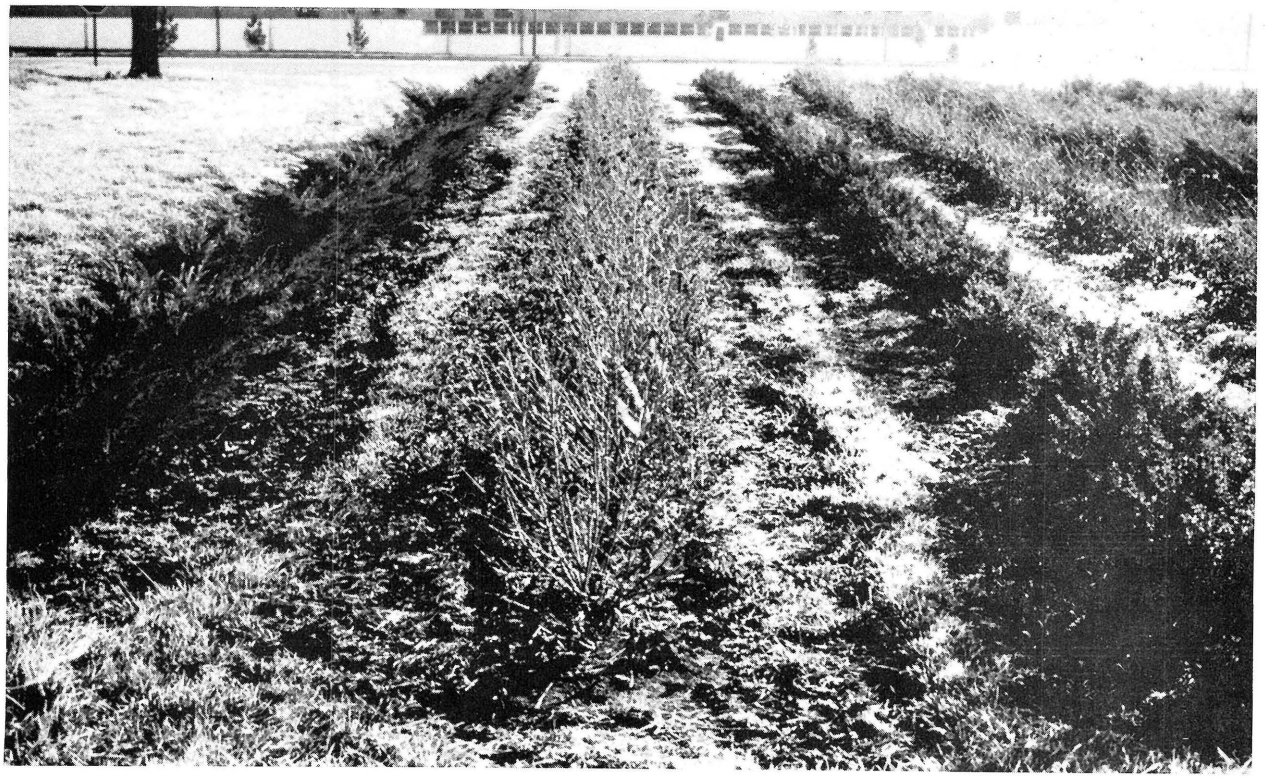

FIG. 1.—Comparison of field grown *Juniperus, Viburnum,* and *Spiraea.* The nine fertility treatments were applied randomly the length of the row. Plants were grown from July 1979 to October 1981. Photo taken October 1981.

Table 2. Effects of the timing of fertilizer application (See Table 1) on dry weight or height of 4 shrub species grown for 2 years.

Juniper

| Treatment | Height (cm)[z] |
|---|---|
| 5 | 42.2 |
| 3 | 39.7 |
| 1 | 39.5 |
| 6 | 38.4 |
| 4 | 37.7 |
| 9 | 35.1 |
| 2 | 34.9 |
| 7 | 34.9 |
| 8 | 31.4 |

Spiraea

| Treatment | Height (cm)[z] |
|---|---|
| 6 | 33.5 |
| 2 | 33.4 |
| 5 | 32.8 |
| 9 | 32.2 |
| 1 | 31.8 |
| 8 | 31.5 |
| 3 | 30.0 |
| 4 | 28.9 |
| 7 | 28.9 |

Taxus

| Treatment | Dry Weight (cm)[z] |
|---|---|
| 7 | 114.6 |
| 6 | 105.4 |
| 5 | 100.3 |
| 8 | 92.9 |
| 9 | 87.3 |
| 1 | 84.9 |
| 2 | 80.3 |
| 3 | 77.5 |
| 4 | 68.9 |

Viburnum

| Treatment | Height (cm)[z] |
|---|---|
| 9 | 68.9 |
| 6 | 67.1 |
| 3 | 64.9 |
| 8 | 64.3 |
| 7 | 64.2 |
| 1 | 63.0 |
| 5 | 62.4 |
| 4 | 62.0 |
| 2 | 61.1 |

[z] F ratios for all species indicated no significant differences among fertility treatments.

Table 3. Effect of rate and timing of fertilizer application on leaf N % of Viburnum plicatum var. tomentosum.

| Treatment | % N[z] |
|---|---|
| 3 | 1.88 a |
| 7 | 1.81 ab |
| 9 | 1.78 abc |
| 2 | 1.77 abcd |
| 6 | 1.75 bcd |
| 4 | 1.69 bcd |
| 5 | 1.67 cd |
| 1 | 1.66 cd |
| 8 | 1.65 d |

[z] Mean separation by Duncan's multiple range test, 5% level.

Table 4. Leaf tissue analysis for % N by species across all fertility treatments.

| Species | % N[z] |
|---|---|
| Spiraea | 2.63 a |
| Taxus | 2.42 b |
| Juniperus | 2.18 c |
| Viburnum | 1.74 d |

[z]Mean separation by Duncan's multiple range test, 5% level.

## SUMMARY

Results of this experiment suggest that timing of fertilizer application may not have a significant effect on plant growth. This would indicate that a slow-release fertilizer, such as the one utilized in this experiment, provided the same response regardless of the time of application. One should remember that using a more soluble form of fertilizer such as ammonium nitrate may not provide the same results as one with a slow-release urea source. Future studies on timing of fertilizer should include slow-release and soluble forms of fertilizer.

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# The Cadmium Content of Eight Ohio Soils

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## ABSTRACT

A study was conducted to determine the cadmium (Cd) concentration of both agricultural and nonagricultural soils in central and northwestern Ohio. The highest Cd concentrations (9.3 and 33.8 ppm) were found in nonagricultural soils adjacent to a zinc oxide plant east of Columbus. Agricultural soils sampled contained close to average (<1 ppm) Cd concentrations.

## INTRODUCTION

Cadmium is a heavy metal of major environmental concern. It is known to reduce growth of several plant species (5, 12) and induce phytotoxicity (4, 5). High soil Cd concentrations are found in soils adjacent to roadways (7) and industrial sites, especially smelting operations (1).

Previous sampling has proved that soil Cd concentrations are inversely related to: 1) distance from the contaminating source, and 2) soil depth (2, 7). Highest Cd concentrations are encountered within the top 5 cm of soil, with 90% of the metal located in the top 15 cm (1). Accumulation is greatest in surface soils where ample adsorption sites exist (6). Organic matter, clay particles, and hydrous oxides of Fe, Al, and Mn readily absorb Cd in the divalent cation form (3). In high concentrations, Cd can replace essential nutrients Ca, Mg, Mn, and K on exchange sites, rendering them highly susceptible to leaching (10). Cadmium can also reduce the decomposition of organic matter (9).

Soils far removed from Cd-emitting sources typically exhibit concentrations <1 ppm (3). Polluted soils can range from 4.56 ppm to 1750 ppm Cd (1, 11). Phytotoxicity and adverse effects on growth parameters have been witnessed on plants grown in soils containing ≥2.5 ppm Cd (5).

## MATERIALS AND METHODS

Eight sampling locations were chosen based on proximity to supposed Cd-emitting sources. Previous studies indicated elevated Zn levels in soils adjacent to a brass smelter in Montpelier, Ohio, (8) and a zinc oxide plant in Columbus, Ohio (Madry, personal communication). As high soil Cd concentrations are associated with high levels of Zn (1, 3), it was hypothesized that Cd levels could also be elevated in these locations. Therefore, soils in these locations as well as soils close to roadways were analyzed. Eight samples, 53 $cm^{-3}$ each, were extracted from the top 15 cm of soil. Samples were air-dried and passed through a 20-mesh stainless steel sieve. Two-gram subsamples (two per sample) were digested in a 5:2 nitric-perchloric digest and Cd levels were determined by a Jarell-Ash MVAA atomic absorption spectrophotometer. Percent base saturation (BS) Mg, Ca, and K, pH, and cation exchange capacity (CEC) were determined for each sample by the Research Extension Analytical Laboratory at the Ohio Agricultural Research and Development Center, Wooster.

## RESULTS AND DISCUSSION

Sampling results are listed in Table 1. The highest Cd concentrations were found in the nonagricultural soils near the zinc oxide plant. Even though these levels are elevated, it is doubtful that Cd mobilization would be excessive due to the high pH of the soils. Cadmium release from soil exchange sites increases as soil pH decreases (3).

All agricultural soils were found to contain Cd concentrations close to the average (3), even though samples were taken from areas targeted as potentially high in Cd content.

The results of this study provide a range of existing Cd concentrations of various soils in central and northwestern Ohio. This information can be utilized in setting up subsequent studies, which will survey plant-soil-Cd relationships and their implications to the residential landscape, nursery, and landscape maintenance industries.

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[1]Graduate Research Associate and Associate Professor, respectively, Dept. of Horticulture.

Table 1. Location and soil characteristics of eight samples.

| Sample # | Land Use | Location | Cd(ppm) | BSMG | BSCa | BSK | pH | CEC |
|---|---|---|---|---|---|---|---|---|
| 1 | Agricultural | U.S. 68 (2 lane)<br>10.2 km S of Dunkirk<br>9.9 m from road | 0.4 | 26 | 77 | 1.2 | 7.1 | 13 |
| 2 | Agricultural | I-75 (4-lane)<br>.21 km N of U.S. 30<br>exit<br>17.1 m from interstate | 0.9 | 18 | 44 | 2.4 | 6.3 | 13 |
| 3 | Agricultural | S.R. 15 (2-lane)<br>.4 km SW Chase Brass*<br>Montpelier, OH<br>9 m from road | 1.0 | 22 | 75 | 2.8 | 7.0 | 15 |
| 4 | Agricultural | .21 km S of Chase Brass*<br>Montpelier, OH | 0.5 | 2.4 | 73 | 3.0 | 7.1 | 13 |
| 5 | Agricultural | .4 km SE of Chase Brass*<br>Montpelier, OH | 1.2 | 16 | 83 | 1.6 | 7.2 | 14 |
| 6 | Agricultural<br>(Landscape Nur-<br>sery) | U.S. 33 (4-lane)<br>3.5 km W of S.R. 161 exit<br>23.4 m from highway | 0.5 | 20 | 56 | 2.8 | 6.9 | 17 |
| 7 | Abandoned<br>Residence | .4 km NE of ASARCO**<br>Columbus, OH | 9.2 | 9 | 90 | 1.2 | 7.4 | 20 |
| 8 | Playground | .21 km E of ASARCO**<br>Columbus, OH | 33.8 | 15 | 82 | 2.5 | 7.2 | 8 |

*Smelting operation

**Zinc oxide plant

# Tolerance of Landscape Crops to Fusilade and Poast

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## ABSTRACT

Fusilade at 0.5 lb ai/A was non-injurious to 26 of 28 landscape crop species treated, while Poast at 0.5 lb ai/A seriously injured four species when applied as over-the-top sprays. Both compounds were too injurious for the majority of the species evaluated when applied at 2.0 lb ai/A.

## INTRODUCTION

Two post-emergence herbicides, Fusilade (fluazifop-butyl) and Poast (sethoxydim), were labeled to control grasses in landscape crops in 1983. These products are recommended for over-the-top spray application to control both annual and perennial grasses in selected landscape crops. Only a limited number of crops are specified on the labels of the two compounds and these represent only a very small fraction of the more than 1,000 different landscape crops produced and grown in Ohio.

Poast is labeled only for use with the following 15 species: azalea, cotoneaster, dogwood, euonymus, fir, forsythia, holly, juniper, magnolia, maple, oak, periwinkle, pine, poplar, and spruce. Fusilade is labeled for 20 species including alyssum, arborvitae, cinquefoil, dogwood, Douglas fir, English ivy, euonymus, fir, forsythia, hemlock, holly, Japanese snowball, lily, turf, periwinkle, pine, privet, rhododendron, spruce, and yew.

Previous research has shown that there is considerable tolerance to these compounds but the research is limited to only a very few species and cultivars (1, 2).

This study was undertaken to aid in label expansion of these two compounds and to determine the tolerance level of a wider variety of crops.

## MATERIALS AND METHODS

Twenty-eight selections of evergreen, deciduous, and herbaceous landscape crops were treated with Fusilade and Poast on July 7, 1983. The plants listed in Tables 1 and 2 were grown at The Ohio State University Research Nursery. Plants were evaluated July 19 or approximately 2 weeks following treatment and August 11 or 6 weeks following application. Fusilade and Poast were applied at the rate of 0.5 lb ai/A and 2.0 lb ai/A. With both materials the equivalent of 1 quart of crop oil concentrate/acre was mixed with the herbicide to aid absorption and the weed killing process. The entire plant was sprayed to the point of run-off. Plants were evaluated using a 10 point scale with 10 best (no injury) and 7 or above acceptable. Three plants per species/treatment were sprayed with three replications.

## RESULTS AND DISCUSSION

On the first evaluation date, July 19, only fragrant sumac was injured at a point considered unacceptable with Fusilade at the 0.5 lb rate (Table 1). Only a trace of injury was noted on Grey owl juniper, snowmound spirea, vicary privet, and McKana giant columbine. Poast at the same rate was noted to cause damage beyond an acceptable level to compact Pfitzer juniper, fragrant sumac, and columbine (Table 2). Slight injury was observed with Grey owl juniper, snowmound spirea, and yellowstem dogwood on July 19. One month later the only plant showing injury at an unacceptable level with either product was Boulevard falsecypress. All other plants outgrew the injury symptoms including fragrant sumac which was injured by Fusilade and compact Pfitzer juniper, fragrant sumac, and columbine which were injured by Poast.

When the rates were increased to 2.0 lb ai/A or 4X the recommended use rate, unacceptable injury was observed on July 19 with 17 species and cultivars treated with Fusilade and 18 species treated with Poast. When re-evaluated at the 6-week interval on August 11, the number of unacceptable plants decreased to seven with Fusilade and six with Poast.

In general, most plants were not injured to an unacceptable level with either Fusilade or Poast when sprayed at the recommended 0.5 lb ai/A rate. However, when the rate was increased to 2.0 lb ai/A, a much higher number of plants were injured. In both cases the injury was temporary and most plants readily outgrew the symptoms.

The symptoms of injury for both products were similar. Herbaceous and deciduous plants revealed temporary stunting of young shoot tips with leaf browning of older leaves. Injury symptoms of blue colored plants such as juniper and Boulevard falsecypress were primarily a change of foliar color from blue to green and some needle browning and shoot tip dieback. Injury to the Boulevard falsecypress progressed with time with both herbicides; it was the only plant where injury became more severe with time.

## SUMMARY

Fusilade and Poast, post-emergence herbicides recently labeled for nursery stock, were evaluated on 28 species of landscape plants. A high degree of tolerance was observed with both compounds at the recommended rate of 0.5 lb ai/A with most crops. When the rate was increased to 2.0 lb ai/A, considerable injury was observed on more than one-half of the test species. Most plants outgrew the injury symptoms with time. Evergreens with blue foliage such as Boulevard falsecypress should not be treated at all and higher rates will be very damaging to blue colored juniper.

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[1] Professor and Technician, Dept. of Horticulture.

Table 1. Tolerance of selected landscape crops to Fusilade applications of 0.5 and 2.0 lbs ai/A two and six weeks following treatment.

| | Fusilade 0.5 lbs ai/A | | Fusilade 2.0 lbs ai/A | |
|---|---|---|---|---|
| | July 19 | Aug. 11 | July 19 | Aug. 11 |
| **Evergreen Landscape Crops** | | | | |
| American Holly | 10[1] | 10 | 10 | 10 |
| Boulevard Falsecypress | 10 | 5 | 5 | 4 |
| Compact Pfitzer Juniper | 10 | 10 | 6 | 7 |
| Cripps Hinoki Falsecypress | 10 | 10 | 4 | 5 |
| Globe Arborvitae | 10 | 10 | 6 | 8 |
| Gold Threadleaf Sawara Falsecypress | 10 | 10 | 4 | 5 |
| Grey Owl Juniper | 9 | 9 | 3 | 3 |
| Hershey Red Azalea | 10 | 10 | 6 | 7 |
| Hicks Yew | 10 | 10 | 8 | 7 |
| Japanese Holly | 10 | 10 | 10 | 10 |
| Lees Dark Purple Rhododendron | 10 | 10 | 6 | 7 |
| Plume Sawara Falsecypress | 10 | 10 | 6 | 7 |
| **Deciduous Landscape Crops** | | | | |
| Billiard Spirea | 10 | 10 | 7 | 9 |
| Compact Burningbush | 10 | 10 | 8 | 8 |
| Compact Cranberrybush Viburnum | 10 | 10 | 6 | 6 |
| Corneliancherry Dogwood | 10 | 10 | 5 | 6 |
| Crispa Spirea | 10 | 10 | 7 | 9 |
| Fragrant Sumac | 6 | 8 | 4 | 6 |
| Gold Drop Potentilla | 10 | 10 | 6 | 7 |
| Newport Red Weigela | 10 | 10 | 7 | 10 |
| Oakleaf Hydrangea | 10 | 10 | 6 | 10 |
| Snowmound Spirea | 9 | 10 | 7 | 7 |
| Spring Glory Forsythia | 10 | 10 | 8 | 10 |
| Tallhedge Buckthorn | 10 | 10 | 7 | 8 |
| Vicary Privet | 9 | 10 | 6 | 7 |
| Yellowstem Dogwood | 10 | 10 | 10 | 9 |
| **Herbaceous Landscape Crops** | | | | |
| Coronation Gold Fernleaf Yarrow | 10 | 10 | 8 | 8 |
| McKana Giant Columbine | 9 | 10 | 5 | 8 |
| Shasta Daisy | 10 | 10 | 6 | 8 |

[1] A visual rating scale of 1-10 was used with 1 = complete crop kill, 10 = no crop injury and 7 or above as acceptable.

Table 2. Tolerance of selected landscape crops to Poast applications of 0.5 and 2.0 lbs ai/A two and six weeks following treatment.

| | Poast 0.5 lbs ai/A | | Poast 2.0 lbs ai/A | |
|---|---|---|---|---|
| | July 19 | Aug. 11 | July 19 | Aug. 11 |
| **Evergreen Landscape Crops** | | | | |
| American Holly | 10[1] | 10 | 9 | 10 |
| Boulevard Falsecypress | 10 | 5 | 8 | 5 |
| Compact Pfitzer Juniper | 6 | 9 | 5 | 8 |
| Cripps Hinoki Falsecypress | 10 | 10 | 10 | 10 |
| Globe Arborvitae | 10 | 10 | 10 | 10 |
| Gold Threadleaf Sawara Falsecypress | 10 | 10 | 6 | 9 |
| Grey Owl Juniper | 8 | 9 | 5 | 6 |
| Hershey Red Azalea | 10 | 10 | 4 | 5 |
| Hicks Yew | 10 | 10 | 7 | 7 |
| Japanese Holly | 10 | 10 | 10 | 10 |
| Lees Dark Purple Rhododendron | 10 | 10 | 6 | 6 |
| Plume Sawara Falsecypress | 10 | 10 | 8 | 10 |
| **Deciduous Landscape Crops** | | | | |
| Billiard Spirea | 10 | 10 | 6 | 9 |
| Compact Burningbush | 10 | 10 | 10 | 10 |
| Compact Cranberrybush Viburnum | 10 | 10 | 6 | 8 |
| Corneliancherry Dogwood | 10 | 10 | 7 | 9 |
| Crispa Spirea | 10 | 10 | 6 | 9 |
| Fragrant Sumac | 6 | 8 | 4 | 6 |
| Gold Drop Potentilla | 10 | 10 | 4 | 7 |
| Newport Red Weigela | 10 | 10 | 5 | 8 |
| Oakleaf Hydrangea | 10 | 10 | 7 | 10 |
| Snowmound Spirea | 9 | 9 | 6 | 8 |
| Spring Glory Forsythia | 10 | 10 | 5 | 8 |
| Tallhedge Buckthorn | 10 | 10 | 6 | 8 |
| Vicary Privet | 10 | 10 | 5 | 8 |
| Yellowstem Dogwood | 9 | 10 | 6 | 6 |
| **Herbaceous Landscape Crops** | | | | |
| Coronation Gold Fernleaf Yarrow | 10 | 10 | 5 | 7 |
| McKana Giant Columbine | 6 | 8 | 5 | 8 |
| Shasta Daisy | 10 | 10 | 6 | 8 |

[1] A visual rating scale of 1-10 was used with 1 = complete crop kill, 10 = no crop injury and 7 or above as acceptable.

# Tolerance of Tulip, Daffodil, and Crocus to Selected Pre-emergence Herbicides

ELTON M. SMITH AND SHARON A. TREASTER[1]

## ABSTRACT

The objective of this evaluation was to determine if Ronstar, Devrinol, Surflan, and Treflan would cause injury to tulip, daffodil, and crocus when applied soon after planting. Ronstar at 4.0 and 16.0 lb ai/A were too injurious with all three species. Devrinol 10G at the X rate (5.0 lb ai/A) was non-injurious to all plants but at the 4X rate (20 lb ai/A) tulip was injured. Devrinol 50W, Surflan 75W, and Treflan 5G all appear safe to use with the three hardy bulb species.

## INTRODUCTION

The control of weeds in hardy bulbs, particularly tulip, daffodil, and crocus, those most frequently planted in the landscape, has long been a problem because only one compound (Betasan) is labeled for these crops (2). Within the past 5 to 6 years several new pre-emergence herbicides have been labeled for the nursery industry but not for use with bulbs. Therefore, a need exists to determine if any of those herbicides can be expected to be safely used without injuring the growth of the bulbous crops. These compounds are being used by maintenance personnel around woody and some herbaceous plants in the landscape. The difficulty, of course, in using pre-emergence herbicides in the landscape from mid-summer until early spring is that the foliage of bulbous crops is no longer present and the applicator may not know to keep the herbicide away from those areas. Thus, a herbicide labeled for woody and/or herbaceous crops that could also be applied to bulbous crops is needed in the industry.

## MATERIALS AND METHODS

Crops selected for this study included: *Tulipa* 'Appledorn' — Appledorn Tulip, *Narcissus* 'Colossal' — Colossal Daffodil, and *Crocus* Mixed Selections — crocus mixture of all commonly planted hardy bulbs. All bulbs were planted Nov. 5, 1982.

The herbicides included: oxadiazon (Ronstar), napropamide (Devrinol), oryzalin (Surflan), and trifluralin (Treflan). The formulations and rates selected were as follows: Ronstar 2G at 4.0 and 16.0 lb ai/A, Devrinol 10G at 5.0 and 20.0 lb ai/A, Devrinol 50W at 5.0 and 20.0 lb ai/A, Surflan 75W at 2.0 and 8.0 lb ai/A, and Treflan 5G at 4.0 and 16.0 lb ai/A. The herbicides were applied Nov. 15, 1982, 10 days following planting. The granular herbicides were applied with a hand-held rotary spreader and the sprayable materials applied with a 3-gallon pump type compression sprayer in approximately 100 gallons of water acre.

The soil composition was a Brookston clay loam soil with a pH of 6.5 and an organic matter content of 2.0%. Each treatment was 150 sq ft in area and replicated three times. All evaluations for phytotoxicity were on a 1 to 10 scale, with 1 equaling complete crop kill, 10 no crop injury, and 7 or above acceptable.

Weed control values are not reported because there was no weed population until the May evaluation and all herbicides resulted in more than acceptable weed control at that date. Data are not reported for phytotoxicity of crocus in March because not all the plants had emerged from the soil and in May the foliage had begun to discolor due to age.

## RESULTS AND DISCUSSION

Previous research has indicated that tulip is somewhat intolerant of herbicides (1). In this study tulip was injured severely with Ronstar at both the 4.0 and 16.0 lb ai/A rates. Devrinol 10G at 5.0 lb ai/A was not injurious but the 4X rate was injurious and below acceptable standards at the April evaluation. Interestingly, Devrinol 50W at either rate did not significantly injure the plants. Surflan at 2.0 and 8.0 lb and Treflan at 4.0 and 16.0 lb ai/A were non-injurious to tulip throughout the spring season.

Narcissus has been reported to be more tolerant of herbicides than tulip (1) and this was true in this study as well. Ronstar at both 4.0 and 16.0 lb ai/A rates injured this crop but all other herbicides were found to be relatively non-injurious throughout the March to May season.

Crocus, like the other two crops, was also severely injured by Ronstar at both rates in the April evaluation. Treflan at the higher rate of 16.0 lb ai/A injured crocus beyond an acceptable level. However, Treflan at the 4.0 lb ai/A rate was an acceptable treatment along with both the granular and wettable powder formulations of Devrinol and Surflan at all rates.

The injury symptoms on tulip from Ronstar and Devrinol G were primarily in the form of twisted and discolored leaves. Ronstar resulted in severe leaf tip browning of narcissus. Premature leaf browning and stunting of the vegetative growth were observed with Ronstar on crocus.

No herbicide treatment consistently resulted in a completely non-phytotoxic situation for any crop on all reporting dates. However, the minor leaf discoloration noted was not enough to significantly reduce vegetative growth or delay bloom except where noted above with the specific crops.

Tulip and crocus were more sensitive to herbicides than narcissus. Ronstar was definitely too injurious for all species. Devrinol 50W and Surflan 75W were non-injurious at both rates to all three species and when labeled would be excellent choices for use in the landscape planted to the bulbous species mentioned above.

[1]Professor and Technician, Dept. of Horticulture.

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Table 1. Tolerance of tulip, daffodil and crocus to selected pre-emergence herbicides.

| Treatment | Rate lb.ai/A | Phytotoxicity[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Tulip | | | Daffodil | | | Crocus | | |
| | | March 16 | April 12 | May 13 | March 16 | April 12 | May 13 | March 16 | April 12 | May 13 |
| Check | -- | 10 | 10 | 10 | 10 | 10 | 10 | - | 10 | - |
| Ronstar 2G | 4.0 | 6 | 5 | 3 | 7 | 6 | 4 | - | 4 | - |
| Ronstar 2G | 16.0 | 4 | 3 | 2 | 6 | 4 | 2 | - | 3 | - |
| Devrinol 10G | 5.0 | 8 | 9 | 9 | 9 | 8 | 8 | - | 8 | - |
| Devrinol 10G | 20.0 | 7 | 6 | 7 | 8 | 9 | 9 | - | 9 | - |
| Devrinol 50W | 5.0 | 8 | 9 | 8 | 8 | 8 | 9 | - | 8 | - |
| Devrinol 50W | 20.0 | 9 | 9 | 10 | 8 | 9 | 8 | - | 9 | - |
| Surflan 75W | 2.0 | 8 | 8 | 8 | 9 | 9 | 8 | - | 8 | - |
| Surflan 75W | 8.0 | 9 | 10 | 9 | 10 | 9 | 9 | - | 8 | - |
| Treflan 5G | 4.0 | 8 | 8 | 9 | 8 | 8 | 9 | - | 8 | - |
| Treflan 5G | 16.0 | 8 | 8 | 8 | 8 | 8 | 8 | - | 6 | - |

[1] Visual scale of 1-10 with 1 = complete crop kill, 10 = no phytotoxicity and 7 or above acceptable.

# A Comparison of White vs. Aluminum Poly for Overwintering Woody Ornamental Landscape Plants

JOHN A. WYNSTRA AND ELTON M. SMITH[1]

## ABSTRACT

Pigmented white and aluminum films of 70% and 80% opacity were evaluated. No clear cut superiority of aluminum film over white film (or vice versa) with respect to plant quality could be determined from results of this experiment. In two of the three cases in which significant differences were found in plant quality between white and aluminum films, white films resulted in better quality. Average soil temperatures and maximum average air temperatures were lowest in white film covered structures. Reduced daytime temperatures have been found to be beneficial to storage of woody ornamentals. Relative humidity was significantly higher in aluminum film covered structures than in structures covered by white films during the sunny day during which data were taken. Results of this study do not indicate that switching the standard nursery overwintering film from white to aluminum would result in improved plant quality.

## INTRODUCTION

Despite the fact that containerized production has proven to be an efficient method of growing woody landscape plants, these plants are more susceptible to winter injury than field grown stock.

Most problems associated with winter injury of container stock are due to their increased vulnerability to low temperature and desiccation injury (4, 6, 7). Soil or media in a container, due to its smaller volume, becomes colder than the natural soil mass. Therefore, roots of container grown plants grown above ground are exposed to lower temperatures than roots of field grown stock in the ground and are consequently more susceptible to winter injury (11).

Polyethylene covered storage structures have been the primary means of winter protection of container stock. To provide optimum protection from winter injury, a polyethylene covered structure should protect against low night temperatures which may cause root damage and high daytime temperatures which may cause desiccation and foliage injury (2, 4, 7, 10).

Much previous work has been done on the relationship of polyethylene films relative to plant quality during storage. Several workers have shown that under clear films (5-10% opacity), the temperature fluctuates greatly and results in lower quality plants than those stored under white films (1, 2, 3, 4, 5, 8, 10, 13). Smith found that at least 70% opacity was necessary to result in acceptable plant quality (11). Rizzo, however, found that black (100% opacity) film was an unsatisfactory covering for most plants, resulting in defoliation of certain species (7).

Aluminum films have been of interest since the mid 1970's. Smith found that maximum day temperatures were lower under aluminum films than white films (10). Rizzo's results concurred with Smith's, and in addition he found that heat loss occurred at a slower rate for aluminum and black films than for white films (7). These results imply that aluminum films are more effective than white films in reducing day/night temperature fluctuations.

The purpose of this study was to compare the merits of white and aluminum films for storage.

## MATERIALS AND METHODS

On Nov. 7 and 8, 1979, 12 15′ x 100′ quonset houses, located in a commercial nursery in central Ohio, were covered with white or aluminum poly pigmented at various opacities.

The treatments consisted of four films: two white films and two aluminum films pigmented at 70% and 80% opacity. There were three replications of each treatment. These films were produced by Canadian Industries Ltd. (CIL), Inc., Willowdale, Ontario. Pigmented films were extruded for this experiment and are not commercially available. References to film type in the tables that follow will be **W** for white and **A** for aluminum.

The plant materials included *Cotoneaster dammeri* 'Royal Beauty', *Pyracantha coccinea* 'Kasan', and *Ligustrum* X 'Vicary'. Ten plants of each cultivar were evenly distributed in three locations within each house.

The plants were evaluated for shoot quality March 21, 1980, using a visual scale of 1-5 with 1 = dead and 5 = no winter injury. Soil temperature data were collected from selected houses representing each of the films with soil thermometers. Air temperature was recorded daily from Dec. 10, 1979, to March 16, 1980, with Taylor Hi-Lo thermometers placed at plant height.

The entire experiment was repeated the following winter (1980-81) with few deviations from the 1979-80 study. The only differences were that during the 1980-81 season, soil temperature data were not taken while relative humidity data were added to the study.

## RESULTS AND DISCUSSION

### Plant Quality

The color pigmentation resulting in the highest visual rating varied depending on the degree of opacity and the species of plant.

After the 1979-80 storage season, privet and cotoneaster shoot quality was significantly higher under white 70% opacity film than under aluminum 70% film. No

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Table 1. Effect of polyethylene films on shoot quality following 1979-81 storage seasor

| Treatment | Quality[x] | | |
|---|---|---|---|
| | Vicary Privet | Kasan Firethorn | Royal Beauty Cotoneaster |
| 1979-1980 Season | | | |
| 70W | 4.1b[y] | 3.6cd | 4.4b |
| 70A | 3.5c | 3.5d | 3.9c |
| 80W | 4.1b | 3.6cd | 4.4b |
| 80A | 4.0b | 3.7cd | 4.7a |
| 1980-81 Season | | | |
| 70W | 4.1ab | 3.1a | 4.9a |
| 70A | 4.7a | 2.3b | 4.6ab |
| 80W | 4.2ab | 2.4ab | 4.9a |
| 80A | 4.6ab | 2.4ab | 4.9a |

[x] Visual rating scale: 1-5 with 5 best

[y] Similar letters in a column are not significantly different at the 5% level accrding to Duncan's Multiple Range Test.

**Table 2. Effect of polyethylene films on average soil temperatures during winter storage 1979-80.**

| Treatments | Temperatures°C |
|---|---|
| 70W | 4.4 |
| 70A | 6.3 |
| 80W | 3.0 |
| 80A | 4.2 |

Table 3. Effect of polyethylene films on average maximum temperatures during winter storage 1979-80

| Treatments | Temperatures°C | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | Avg. |
| 70W | 13.2ab[x] | 8.9c | 13.0ab | 6.0a | 5.7cd | 11.9c | 6.1cd | 4.4cd | 6.3cd | 8.3cd | 8.5bc | 6.1bc | 12.5bc | 8.5 |
| 70A | 14.9a | 14.0a | 15.9a | 7.9a | 9.2a | 16.0a | 10.5a | 9.1a | 12.3a | 13.2a | 11.7a | 11.0a | 17.8a | 12.6 |
| 80W | 11.5ab | 8.7c | 10.7b | 5.3a | 5.1de | 10.8c | 5.3cd | 3.0de | 5.5cde | 7.3cd | 7.8cd | 4.6cd | 11.6c | 7.5 |
| 80A | 14.9a | 12.2b | 14.4ab | 6.0a | 8.0a | 15.3ab | 9.5ab | 7.6ab | 10.3ab | 10.9b | 10.2ab | 9.2a | 15.2ab | 11.1 |
| Outside | 8.9 | 6.3 | 5.0 | -.9 | 3.7 | 10 | 1.8 | -2.8 | -2.1 | -1.7 | 4.1 | -1.6 | 4.4 | 2.7 |

[x] Similar letters in a column are not significantly different at the 5% level according to Duncan's Multiple Range Test.



Table 4. Effect of polyethylene films on average maximum temperatures during winter storage 1980-81.

| Treatments | Temperature °C | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Avg. |
| 70W | 15.8a[x] | 11.6a | 5.7d | 5.3b | 4.2ab | 1.4d | 3.9c | 6.0d | 11.3de | 3.3ab | 7.1bcd | 13.7ab | 16.1bc | 16.0c | 18.4bc | 9.3 |
| 70A | 18.3a | 13.7a | 9.9a | 9.0a | 7.2a | 6.2a | 8.0a | 15.0a | 18.2a | 7.0a | 10.4a | 15.9a | 19.7a | 22.8a | 21.6a | 13.5 |
| 80W | 16.3a | 10.3a | 4.7d | 4.2b | 2.9b | 0.6d | 2.6d | 7.1e | 9.3e | 2.1b | 5.3d | 12.5b | 15.0c | 13.7d | 17.1c | 8.2 |
| 80A | 17.3a | 12.7a | 8.6ab | 7.5ab | 6.4ab | 6.1a | 6.7b | 12.5b | 15.1b | 5.6ab | 9.6ab | 14.3ab | 17.8abc | 19.6b | 20.1ab | 12.0 |
| Outside | 11.1 | 6.3 | -6.0 | -1.3 | -2.4 | -6.1 | -3.8 | 4.5 | 1.8 | -5.1 | 0.0 | 11.6 | 6.2 | 5.1 | 6.4 | 2.2 |

[x] Similar letters in a column are not significantly different at the 5% level according to Duncan's Multiple Range Test.

significant differences in firethorn shoot quality between 70% opacity white and aluminum films were noted (Table 1).

Under the 80% opacity films, shoot quality of cotoneasters was significantly higher under aluminum film than under white pigmented film. No significant differences in shoot quality of privet and firethorn were noted between white and aluminum 80% opacity film (Table 1).

Following the 1980-81 storage season, firethorn shoot quality was significantly higher under 70% opacity film of white pigmentation than that of aluminum. No significant differences in privet and cotoneaster shoot quality were noted between white and aluminum films of 70% opacity (Table 1).

Significant differences in shoot quality of privet, firethorn, and cotoneaster were not observed between white and aluminum films of 80% opacity following the second season.

## Temperature

Average soil temperatures of containers in structures covered with various films were compared during the 1979-80 storage season. The averages were calculated from the sum of soil temperatures recorded during the entire season. The white film covered structures resulted in an average soil temperature of 3.7 C (38.7 F), while the aluminum film covered structures resulted in an average soil temperature of 5.2 C (41.4 F) (Table 2).

Maximum average temperatures in structures covered by white and aluminum films of 70% and 80% opacity were compared with the average outside maximum temperatures of 2.7 C (36.9 F) during the 1979-80 season and 2.2 C (36.0 F) during the 1980-81 season. During the 1979-80 season, the white film covered structures resulted in an average maximum temperature of 8 C (46.4 F), while the aluminum film covered structures resulted in an average maximum temperature of 11.8 C (53.2 F). During the 1980-81 season, the white film covered structures resulted in an average maximum temperature of 8.7 C (47.7 F), while the aluminum film covered structures resulted in an average maximum temperature of 12.7 C (54.9 F) (Tables 4 and 5).

Maximum temperatures in structures covered by aluminum 70% and 80% opacity film were significantly higher than those in structures covered by white film for 10 of the 13 weeks that temperature was recorded in 1979-80 and for 10 of the 15 weeks during which temperature was recorded in 1980-81 (Tables 3 and 4). These higher maximum temperatures under aluminum film covered structures are in agreement with soil temperature data of this study but in contrast with work done by Smith (10).

Significant differences in minimum temperatures among film covered structures were not noted for any week during either the 1979-80 or the 1980-81 storage seasons (Tables 5 and 6). This lack of variation in minimum temperatures is in agreement with previous work done by Smith (10).

## Relative Humidity

Relative humidity in both white and aluminum film covered structures was compared with the average outside relative humidity during the 1980-81 storage season.

During the first test taken on a cloudy day in January 1981, the average outside relative humidity was 66%. There was a 4% difference between the highest relative humidity reading of 87% in the 80W and the lowest reading of 83% in the 80A covered structure. The average of the white film covered structures was 86% or 25% higher than outside. The average of the structures covered by aluminum films was 84.5% or 18.5% higher than the outside (Table 7).

During the second test taken on a sunny day in March, the average outside relative humidity was 35%. The difference in humidity in structures between the highest relative humidity reading of 82% (70A and 80A) and the lowest reading of 68% (70W) was 14%. The average of the white film covered structures was 68.5% or 33.5% higher than the outside. The average of the structures covered with aluminum films was 82% which was 47% higher than the outside average relative humidity (Table 7).

The effect of the film color on the relative humidity inside the structures appeared to vary depending on whether conditions were cloudy or sunny. On the sunny March day, the aluminum film covered structures had significantly higher relative humidities than structures covered with white films. On the cloudy day in January, however, differences in relative humidity under white and aluminum films were not pronounced. Structures covered with white films of 80% opacity had significantly higher relative humidities than structures covered with aluminum films of 80% opacity, but significant differences among the other films were not observed (Table 7).

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Table 5. Effect of polyethylene films on average minimum temperatures during winter storage 1979-80.

| Treatments | Temperature °C | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | Avg. |
| 70W | -2.0a[x] | -4.8a | -2.6a | -2.3ab | -4.3a | -.6a | -3.9a | -8.2b | -9.0a | -7.1a | -3.1a | -8.0a | -4.9a | -4.7 |
| 70A | -2.1a | -5.3a | -3.0a | -3.1b | -4.8a | -.2a | -4.4a | -8.3b | -8.6a | -7.0a | -2.6a | -7.7a | -4.5a | -4.7 |
| 80W | -2.6a | -5.3a | -3.3a | -2.9b | -4.6a | -.6a | -4.5a | -9.0b | -9.1a | -7.5a | -2.6a | -8.2a | -5.1a | -5.0 |
| 80A | -1.6a | -4.8a | -1.9a | -3.1b | -4.6a | -.0a | -4.4a | -7.4ab | -8.0a | -6.5a | -2.6a | -7.5a | -4.7a | -4.4 |
| Outside | -2.3 | -2.8 | -1.4 | -4.1 | -6.4 | -.4 | -6.1 | -13.7 | -11.9 | -11.6 | -4.5 | -11.3 | -7.9 | -6.5 |

[x] Similar letters in a column are not significantly different at the 5% level according to Duncan's Multiple Range Test



Table 6. Effect of polyethylene films on average minimum temperatures during winter storage 1980-81.

| Treatments | Temperature °C | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Avg. |
| 70W | -3.3a[x] | -1.7a | -3.5a | -5.4a | -3.9a | -10.3a | -7.1a | -3.8a | -5.2a | -10.4a | -8.4a | -3.6a | -8.0a | -2.7a | -2.5a | -4.1 |
| 70A | -3.0a | - .7a | -3.2a | -5.3a | -4.0a | -10.4a | -7.0a | -3.7a | -5.2a | - 9.3a | -8.3a | -3.6a | -1.1a | -2.1a | -3.0a | -4.1 |
| 80W | -2.9a | -1.2a | -3.0a | -5.4a | -5.1a | -10.1a | -7.0a | -4.0a | -4.9a | -10.0a | -8.7a | -3.3a | -1.3a | -2.3a | -2.7a | -4.2 |
| 80A | -2.1a | -1.5a | -2.7a | -4.4a | -3.7a | -10.4a | -7.1a | -2.9a | -4.1a | - 9.0a | -7.3a | -3.2a | - .5a | -1.8a | -2.4a | -3.6 |
| Outside | -2.6 | - .4 | -8.6 | -11.6 | -8.6 | -18.8 | -11.1 | -3.2 | -7.2 | -14.1 | -9.4 | -2.7 | - .9 | -3.3 | -3.3 | -6.4 |

[x] Similar letters in a column are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Table 7. Effect of polyethylene films on relative humidity during winter storage 1980-81.

| Treatment | Relative Humidity (%) | |
|---|---|---|
| | January (Cloudy) | March (Sunny) |
| 70W | 85abcd* | 68b |
| 70A | 86abc | 82a |
| 80W | 87ab | 69b |
| 80A | 83cd | 82a |
| Outside | 66e | 35c |

* Similar letters in a column are significantly different at the 5% level according to Duncan's Multiple Range Test.


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# Evaluation of Flowering Crabapple Susceptibility to Apple Scab in Ohio—1983

ELTON M. SMITH[1]

## ABSTRACT

The spring of 1983 was cool and very wet with some rainfall recorded for each of 13 consecutive weeks. Consequently, apple scab was observed to be very prevalent during this growing season. In total, 116 selections of flowering crabapple were found to be susceptible or highly susceptible and 88 selections were resistant or highly resistant.

## INTRODUCTION

One of the most serious diseases of flowering crabapple in Ohio is apple scab caused by the fungus *Venturia inequalis*. Infection by this fungus results in the formation of olive gray spots on the foliage which often lead to yellowing and defoliation. Extensive leaf fall not only destroys the landscape value of a tree but may leave the plants in a weakened condition as they enter winter, and flowering the following season is also reduced.

This disease can be controlled by regular spraying with one of several fungicides; however, to avoid the disease and subsequent spraying in future plantings, resistant selections should be planted. Many selections are highly resistant or nearly resistant to apple scab and these are the types which should be commercially propagated and produced, assuming their horticultural qualities are acceptable to the consumer and producer. Horticultural qualities have been reviewed in a publication titled "The Flowering Crabapple—A Tree for All Seasons" (1).

## MATERIALS AND METHODS

Flowering crabapples located in arboretums and nurseries were surveyed in August 1983 for the severity of apple scab infection and for the presence of other diseases such as cedar apple rust and fireblight. The latter diseases were not rated because they are usually not serious enough in Ohio to discontinue the planting of a species, hybrid, or cultivar.

Rainfall, which influences the severity of certain diseases, was above normal in much of Ohio during the April-May period and the severity of apple scab was higher than in previous years (2).

The scale used for apple scab evaluations was as follows: HR = highly resistant—no indication of disease; R = resistant—mild infection with no defoliation; S = susceptible—medium infection with only slight defoliation; and HS = highly susceptible—heavy infection often accompanied by considerable defoliation. In some instances more than one notation appears in the table for a given selection because the severity of infection varied from location to location. This variation was due to differences in frequency of rainfall and relative humidity in the various locations in Ohio.

## RESULTS AND DISCUSSION

The number of flowering crabapple selections found to be susceptible or highly susceptible to apple scab numbered 116, while 88 selections were resistant or highly resistant.

Among the most disease-resistant types in 1983 in Ohio were 'Bob White', 'David', 'Dolgo', *M. floribunda* 'Golden Gem', 'Golden Hornet', *M. halliana* 'Parkmanni', *M. hupehensis*, 'Indian Summer', 'Liset', 'Makamik', *M.* x *micromalis*, 'Prairie Rose', *M. sargenti*, *M. sieboldi* 'Fuji', 'Silver Moon', 'Sugartyme', White Angel, and *M. zumi* 'Calocarpa'.

Selections with more disease symptoms than in 1982 (3) included 'Barbara Ann', Centurion, Mary Potter, Robinson, Spring Snow, and Snowdrift.

The most disease susceptible selections were 'American Beauty', *M. atrosanguinea* 'Dorothea', 'Flame', 'Henry Dupont', 'Hopa', 'Katherine', 'Pink Cascade', 'Pink Weeper', 'Purple Wave', 'Aldenhamensis', 'Eleyi', 'Lemoinei', 'Radiant', Red Silver, 'Spring Snow', and Tanner. Each of these 17 selections should be considered for discontinuation from commercial production. The highly resistant selections, however, should be given the highest consideration by the nursery industry for commercial production.

For additional information relative to horticultural qualities such as habit of growth, flower, foliage, and fruit, visit an arboretum with a collection of flowering crabapples such as the Secrest Arboretum in Wooster, Dawes Arboretum near Newark, and the Holden Arboretum in Mentor.

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Table 1. Susceptibility of Flowering Crabapples to Apple Scab--1983.

| Species, Hybrid or Cultivar | Apple Scab Rating* | | | | Other Diseases Noted |
|---|---|---|---|---|---|
| | HR | R | S | HS | |
| 'Adams' | | X | | | |
| M. x adstringens | | | | X | |
| 'Almey' | | | | X | |
| 'American Beauty' | | | | X | |
| 'Amisk' | | | | X | |
| 'Amur' | | | | X | |
| M. x arnoldiana | | | X | | |
| 'Arrow' | | | | X | |
| M. x atrosanguinea | | | | X | |
| M. baccata | | X | | | |
| M. baccata columnaris | | | | X | |
| M. baccata 'Jackii' | X | | | | Fireblight |
| M. baccata var. Mandshurica | | X | X | | |
| M. baccata 'Midwest' | X | | | | |
| 'Barbara Ann' | | | | X | |
| 'Beverly' | X | X | | | |
| 'Bob White' | X | | | | |
| 'Brandywine' | | X | | | |
| M. brevipes | | | | X | |
| 'Burgundy' | | | X | | |
| 'Calloway' | X | | | | |
| 'Candied Apple' | | X | | | |
| 'Cashmere' | | | | X | |
| 'Centennial' | X | X | | | |
| 'Centurion' | | | X | | |
| 'Cheal's Crimson' | | | | X | |

Table 1 (continued) Susceptibility of flowering crabapples to apple scab-1983

| Species, Hybrid or Cultivar | Apple Scab Rating | | | | Other Diseases Noted |
|---|---|---|---|---|---|
| | HR | R | S | HS | |
| 'Chestnut' | X | | | | |
| 'Chilko' | | X | | | |
| 'Christmas Holly' | X | | | | |
| 'Coralburst' | X | X | | | |
| M. coronaria 'Charlottae' | | | | X | |
| M. coronaria 'Dasycalyx | | | | X | Fireblight |
| M. coronaria Nieuwlandiana | | | | X | |
| 'Cowichan' | | | | X | |
| 'Crimson Brilliant' | | | | X | |
| 'Dainty' | | X | X | | |
| 'Dauphin' | | | | X | |
| 'David' | X | | | | |
| 'Dolgo' | X | | | | |
| 'Donald Wyman' | | X | | | |
| 'Dorothea' | | | | X | |
| 'Ellen Gerhart' | | | X | X | |
| 'Evelyn' | | | X | | |
| 'Exzellenz Theil' | | | | X | |
| 'Flame' | | | | X | |
| 'Flexilis' | X | | | | |
| M. florentina | X | | | | |
| M. floribunda | X | | | | |
| 'Fusca' | | X | | | |
| 'Geneva' | | X | | | |
| 'Gorgeous' | | X | | | |

Table 1 (continued) Susceptibility of flowering crabapples to apple scab--1983

| Species, Hybrid or Cultivar | Apple Scab Rating | | | | Other Diseases Noted |
|---|---|---|---|---|---|
| | HR | R | S | HS | |
| M. glaucescens | X | | | | |
| M. gloriosa | | | | X | |
| 'Golden Gem' | X | | | | |
| 'Golden Hornet' | X | | | | |
| 'Gwendolyn' | X | | | | Fireblight |
| M. halliana | X | | | | |
| M. halliana 'Parkmanii' | X | | | | |
| M. x hartwigii | X | | | | |
| 'Harvest Gold' | | X | | | |
| 'Henrietta Crosby | | | | X | |
| 'Henry Dupont' | | | | X | |
| 'Hopa' | | | | X | |
| 'Hopa Dwarf' | | | | X | |
| 'Hopa Rosea' | | | | X | |
| M. hupehensis | X | | | | |
| 'Indian Magic' | | X | X | | |
| 'Indian Summer' | X | | | | |
| M. ioensis | | X | | | |
| M. ioensis 'Klehms' | X | | | | |
| 'Klehms Improved' | X | | | | |
| 'Irene' | | | | X | |
| 'Jay Darling' | | | | X | |
| 'Joan' | X | | | | |
| 'Katherine' | | | | X | |
| 'Kingsmere' | | | | X | |
| 'Kinghisorum' | X | | | | |

Table 1 (continued) Susceptibility of flowering crabapples to apple scab--1983

| Species, Hybrid or Cultivar | Apple Scab Rating | | | | Other Diseases Noted |
|---|---|---|---|---|---|
| | HR | R | S | HS | |
| M. lancifolia | | | | X | |
| M. lancifolia 'Allegheny' | | | | X | |
| 'Leslie' | | X | | | |
| 'Liset' | X | | | | |
| 'Madonna' | X | | | | |
| M. x magdeburgensis | | | | X | |
| 'Makamik' | X | | | | |
| 'Marshall Oyama' | | X | X | | |
| 'Mary Potter' | | X | X | | |
| 'Masek' | | | | X | |
| M. x micromalus | X | | | | |
| M. 'Neville Capeman' | | | | X | |
| 'Oakes' | | | | X | |
| 'Oekonomierat Echtermeyer' | | | | X | |
| 'Ormiston Roy' | X | | | | Fireblight |
| 'Patricia' | | | | X | |
| 'Pink Beauty' | | | X | | |
| 'Pink Cascade' | | | | X | |
| 'Pink Flame' | | | X | | |
| 'Pink Perfection' | | | X | | |
| 'Pink Spires' | | X | X | | |
| 'Pink Weeper' | | | | X | |
| 'Prairie Rose' | X | | | | |
| 'Pretty Marjorie' | | | X | | |
| 'Prince Georges' | X | X | | | Cedar Apple Rust |

Table 1 (continued) Susceptibility of flowering crabapples to apple scab--1983

| Species, Hybrid or Cultivar | Apple Scab Rating | | | | Other Diseases Noted |
|---|---|---|---|---|---|
| | HR | R | S | HS | |
| 'Profusion' | | X | X | | |
| M. prunifolia | | | | X | |
| M. prunifolia 'Pendula' | X | | | | |
| M. prunifolia var. rinkii | | | | X | |
| M. pumila 'Elise Rathke' | | | | X | |
| M. pumila 'Niedzwetzkyana' | | | | X | |
| M. pumila 'Paradise Foleus Aureus' | | | X | | |
| 'Purple Wave' | | | | X | |
| M. purpurea | | | | X | |
| M. x purpurea 'Aldenhamensis' | | | | X | |
| M. x purpurea 'Eleyi' | | | | X | |
| M. x purpurea 'Lemoinei' | | | | X | |
| 'Radiant' | | | | X | |
| 'Ralph Shay' | | | X | X | |
| 'Red Baron' | | X | X | | |
| 'Red Bud' | X | | | | |
| 'Red Edinburgh' | | | | X | |
| 'Redfield' | | | | X | |
| 'Redflesh' | | | | X | |
| 'Red Jade' | | X | X | | |
| 'Red Jewel' | | X | | | |
| 'Red Silver' | | | | X | |
| 'Red Splendor' | | | | X | |
| 'Robinson' | | | X | X | |
| M. x robusta | X | | | | |
| M. x robusta 'Erecta' | | X | X | | |

Table 1 (continued) - Susceptibility of flowering crabapples to apple scab--1982.

| Species, Hybrid or Cultivar | Apple Scab Rating | | | | Other Diseases Noted |
|---|---|---|---|---|---|
| | HR | R | S | HS | |
| M. x robusta 'Leucocarpa' | X | | | | |
| M. robusta 'Persicifolia' | X | | | | |
| 'Rose Tea' | X | | | | |
| 'Rosseau' | X | | | | |
| 'Rosybloom' | | | X | | |
| 'Royal Ruby' | | | | X | |
| 'Royalty' | | | X | | |
| 'Rudolf' | | | X | X | |
| M. sargentii | X | | | | |
| M. sargentii 'Rosea' | | X | X | | |
| M. x scheideckeri | | | X | | |
| M. x scheideckeri 'Hillieri' | | | | X | |
| 'Scugog' | | X | X | | |
| 'Selkirk' | | X | | | |
| 'Sentinel' | | | X | | |
| 'Shakespeare' | | | | X | |
| M. sieboldi | | X | X | | |
| M. sieboldi var. arborescens | | X | | | |
| M. sieboldi 'Fuji' | X | | | | |
| M. sikkimensis | x | | | | |
| 'Silver Moon' | X | | | | |
| 'Simcoe' | X | X | | | |
| 'Sissipuk' | X | | | | |
| 'Snowbank' | X | | | | Fireblight |
| 'Snowcap' | | | X | | |
| 'Snowcloud' | | X | X | | |

Table 1 (continued) - Susceptibility of flowering crabapples to apple scab--1982.

| Species, Hybrid or Cultivar | Apple Scab Rating | | | | Other Diseases Noted |
|---|---|---|---|---|---|
| | HR | R | S | HS | |
| 'Snowdrift' | | | X | | |
| M. x soulardii | | | | X | |
| 'Sparkler' | | | X | | |
| M. spectabilis | | | | X | |
| M. spectabilis 'Albi-Plena' | | | X | X | |
| M. spectabilis 'Riversii' | | | X | | |
| M. spectabilis 'Van Eseltine' | | | | X | Fireblight |
| 'Spring Snow' | | | | X | |
| 'Strathmore' | | | | X | |
| M. x sublobata | | | X | X | |
| 'Sugartyme' | X | | | | |
| 'Sundog' | | | X | | |
| M. sylvestris 'Plena' | | | | X | |
| 'Tanner' | | | | X | |
| M. toringoides | | | | X | |
| M. toringoides 'Macrocarpa' | | | | X | |
| 'Trail' | | X | | | |
| M. tschonoski | X | | | | Fireblight |
| 'Turesi' | | | | X | |
| 'Valley City #4' | | X | X | | |
| 'Vanguard' | | | X | | |
| 'Velvet Pillar' | | X | X | | |
| 'Wabiskaw' | | | | X | Fireblight |
| 'White Angel' | X | | | | |
| 'White Candle' | | X | X | | |
| 'Wickson' | | | X | | |
| 'Wilson' | | | | X | |

Table 1 (continued) - Susceptibility of flowering crabapples to apple scab--1982.

| Species, Hybrid or Cultivar | Apple Scab Rating | | | | Other Diseases Noted |
|---|---|---|---|---|---|
| | HR | R | S | HS | |
| 'Winter Gold' | | | | X | |
| 'Wooster No. 1' | X | | | | |
| M. yunnanensis 'Veitchi' | X | | | | |
| M. yunnanensis 'Veitch's Scarlet' | X | | | | |
| M. zumi | | X | X | | |
| M. zumi 'Calocarpa' | X | | | | |

# Annual Fixed Costs of Operating Container Nurseries in Ohio Differentiated by Size of Firm and Species of Plant

REED D. TAYLOR, HAROLD H. KNEEN, DAVID E. HAHN, AND ELTON M. SMITH[1]

## ABSTRACT

The objective of this study was to determine annual fixed costs of operating container nurseries in Ohio differentiated by size of firm and species of plant. Differences in fixed costs between plant species were totally determined by space requirements for production. In the smaller of the two nurseries analyzed, annual fixed costs per 2-gallon salable plant by species ranged from $1.90 to $3.72 and averaged $2.53. In the larger nursery, comparable costs were $1.50, $3.00, and $2.04. This approximate 25% gain in efficiency when going from the small to the large nursery is attributable to the more efficient use of buildings, machinery, and equipment of the large nursery over the small. Fixed costs as a percentage of total costs in the small nursery ranged from 42% to 51%, averaging 46% across species. Comparable values for the large nursery were 37%, 46%, and 42%.

## INTRODUCTION

Nurserymen throughout the United States have been gradually shifting from field to container production for many species of plants. Containers allow greater flexibility in production and marketing and in most cases are less expensive than field production (4). Consequently, this has encouraged large companies to enter production and marketing. The result has been escalating competition and narrowing profit margins. Many nurserymen also lack the necessary expertise to systematically determine production costs. Due to increasing competition and periodically a slack economy, many nursery operators find themselves in a precarious financial position. Survival under these conditions requires excellent production and marketing procedures. The purpose of this research is to provide nursery operators with production and financial information for decision making. This information should prove especially useful to individuals anticipating beginning a container nursery and to present field operators anticipating expanding to containers. It should also prove useful to present nurserymen with container operations who anticipate updating and expansion. Another value would be in identifying present operations that might be bottlenecks causing inefficiencies.

Cost models have recently been developed for several species of plants in other areas (1, 2, 3, 8, 10, 11, 12, 13, 14). An initial cost model for Ohio was developed by Powers (9) which provided excellent information. However, it did not include overhead costs or information on physical coefficients. The lack of physical coefficients makes it very difficult to update the information without resurveying nurserymen. Kneen developed complete cost models for both container and field grown *Juniperus chinensis* 'Pfitzeriana' for U.S.D.A. climatic zones 6 and 7 using the economic engineering concept (4). Information from Kneen's study was updated in 1982 and a portion of the material published in 1983 (5, 6). Kneen's study if expanded to include other species of plants would provide a standard against which Ohio nurserymen could compare their own operations. This type of information would allow present or potential Ohio nurserymen to make more informed decisions as to whether to enter, leave, or expand container production.

The specific objective of the study was to determine annual fixed costs of operating container nurseries in Ohio differentiated by size of firm and species of plant.

## MATERIALS AND METHODS

In the study, two model firms were synthesized using the conceptual framework of economic engineering wherein the 'best proven practice' was included in each model. They were synthesized based on the Columbus, Ohio, area. The complete synthesis included developing an appropriate production cycle; schematic drawings of the physical layout, including buildings and irrigation system; lists of equipment and other items; a complete sequence by month and year of nursery operational steps beginning with the purchase of plant liners and ending with loading the finished product for wholesale distribution; and budgets for fixed and variable costs (4, 5, 6, 7).

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during 1982. The basic goals in synthesizing the production facilities were to minimize labor expenses, flow and movement of plant material and equipment, water runoff, and initial investment, and to maximize the number of salable plants and keep future expansion possible.

The production system chosen for this analysis consists of utilizing husky 2 or 3-year-old bareroot liners to produce a salable plant within two growing seasons. These 6-7" liners are transplanted directly into 2-gallon (8 ½" x 8") copolymer containers during the month of May. Approximately 10% of the crop will be sold during the fall of the second growing season (approximately 18 months), 65% during March and April after the second growing season (approximately 22-23 months), and 25% during May after the second growing season (24 months). May is a period when clean-up sales are being made and new plants started. This production system

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saves transplanting as the plants are sold in the same containers in which they are started (2 gallon).

The nursery operations were assumed to produce a diverse line of nursery stock each having a 2-year production cycle. Commonly grown nursery stock was divided into five cultural groups. While not all inclusive, the groups do permit a range of per unit costs to be developed as they relate to input costs and cultural factors. For analytical purposes, it was assumed that each cultural group would occupy 20% of the growing area (*i.e.*, small nursery = 68,000 sq ft per group; large nursery = 136,000 sq ft per group). The small container operation would be comprised of 198,745 units in full production and the large operation of 399,160 units. Annual sales capacity for the small operation would be 95,650 units and for the large operation 192,095 units. For detailed analysis, one specific plant from each group was chosen as representative of the group. While it is recognized that other plants from each category would have somewhat different requirements, it was felt that the requirements would not vary significantly in cost from the plant chosen as representative. The five groups, with some of their cultural characteristics, are listed below:

| GROUP | PLANT | CULTURAL CHARACTERISTICS |
|---|---|---|
| I | **Spreading Evergreens**<br>*Juniperus chinensis* (varieties)<br>*Juniperus horizontalis* (varieties)<br>*Thuja occ. woodwardi* | Hardwood bark medium, minimal overwinter structure, 12-15" salable plants |
| II | **Spreading Deciduous Shrubs**<br>*Berberis t.* 'Crimson Pygmy'<br>*Cotoneaster apiculata*<br>*Cotoneaster horizontalis*<br>*Cotoneaster dammerii*<br>*Euonymus fortunei* | Hardwood bark medium, maximum overwinter structure, 12-15" salable plants |
| III | **Slow-growing Evergreens**<br>*Taxus* (species)<br>*Buxus* (species) | Pinebark medium, minimal overwinter structure, 12-15" salable plants |
| IV | **Upright Deciduous Shrubs**<br>*Euonymus alatus compacta*<br>*Viburnum* (species)<br>*Weigela*<br>*Forsythia*<br>*Ligustrum vicaryi* | Hardwood bark medium, minimal overwinter structure, 18-24" salable plants |
| V | **Broadleaf Evergreens**<br>*Rhododendron*<br>*Pieris*<br>*Pyracantha* | Pinebark medium, maximum overwinter structure, 15-18" salable plants |

Space requirements for different periods of the growing cycle, total plants in production, salable plants per year, and capital requirements per salable plant capacity by plant grouping were determined (Tables 1 and 1a). Space requirements directly determine the annual number of plants available for sale and thereby exert a significant impact on costs of production.

Most nurseries use cash rather than accrual accounting procedures. For this reason, the analyses were completed on a "cash" basis. Analysis on a cash basis does not give a true economic picture of the cost of producing a plant as it does not take into account the time value of money from the time the plant is planted until it is sold. The analyses do, however, give a true estimate of the annual fixed cost per salable plant.

Costs were established for all factors of production contributing to fixed costs including management and invested capital. In economic terms, costs associated

TABLE 1.--Capacity in Number of Plants and Capital Required per Salable Plant Capacity by Spacing for a Small* Container Nursery in Ohio, 1982.

| Group | Growing Cycle Spacing | | | | Production factors | | |
|---|---|---|---|---|---|---|---|
| | Growing Season On-center (inch) | First Year Over-Wintering (inch) | Second Growing Season On-center (inch) | Second Year Over-Wintering (inch) | Total Plants in Production (units) | Salable Plants per Year (units) | Capital Requirements per Salable Plant Capacity (dollars) |
| I - Juniperus | 9 | 9 | 15 | 12 | 53,120 | 25,600 | 4.63 |
| II - Cotoneaster | 12 | 9 | 15 | 15 | 43,095 | 20,730 | 5.72 |
| III - Taxus | 9 | 9 | 18 | 15 | 41,750 | 20,085 | 5.90 |
| IV - Viburnum | 12 | 12 | 21 | 15 | 33,655 | 16,185 | 7.33 |
| V - Rhododendron | 12 | 12 | 18 | 18 | 27,125 | 13,050 | 9.09 |
| Totals | | | | | 198,745 | 95,650 | 6.20 |

*Total Nursery - 17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space. Each group of plants would occupy 20 percent of the growing (60,000 sq ft) and polyhouse (40,800 sq ft) space.

TABLE 1a.--Capacity in Number of Plants and Capital Required per Salable Plant Capacity by Spacing for a Large* Container Nursery in Ohio, 1982.

| Group | Growing Cycle Spacing | | | | Production factors | | |
|---|---|---|---|---|---|---|---|
| | Growing Season On-center (inch) | First Year Over-Wintering (inch) | Second Growing Season On-center (inch) | Second Year Over-Wintering (inch) | Total Plants in Production (units) | Salable Plants per Year (units) | Capital Requirements per Salable Plant Capacity (dollars) |
| I - Juniperus | 9 | 9 | 15 | 12 | 107,900 | 52,000 | 3.71 |
| II - Cotoneaster | 12 | 9 | 15 | 15 | 86,180 | 41,455 | 4.65 |
| III - Taxus | 9 | 9 | 18 | 15 | 83,505 | 40,165 | 4.80 |
| IV - Viburnum | 12 | 12 | 21 | 15 | 67,320 | 32,380 | 5.96 |
| V - Rhododendron | 12 | 12 | 18 | 18 | 54,255 | 26,095 | 7.39 |
| Totals | | | | | 399,160 | 192,095 | 5.02 |

*Total Nursery - 33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space. Each group of plants would occupy 20 percent of the growing (136,000 sq ft) and polyhouse (81,600 sq ft) space.

with factors of production inputted by owner/operators are often referred to as 'opportunity costs' or the income these factors could have received if they were employed elsewhere. For example, owners could usually be employed as managers at other nurseries, and money invested in land, buildings, irrigation systems, and equipment could have earned interest if it had been placed in financial institutions.

Based upon capital requirements for establishing Ohio container nurseries as previously reported (5), annual fixed costs were determined (Tables 2 and 2a). Annual fixed costs per cultural group were then determined by dividing total fixed costs by five (Tables 3 and 3a). Based on these figures, fixed costs per salable plant were calculated (Tables 4 and 4a). These analyses allowed cost comparisons based on cultural practices and size of nursery. See Taylor *et al.* (5) for details on specific fixed costs. Annual variable and total costs of producing specific species of plants are reported in companion articles in this publication (pages 39 to 59). An analysis of annual costs of producing *Juniperus chinensis* 'Pfitzeriana' was previously reported (6).

## RESULTS AND DISCUSSION

Annual fixed costs associated with capital investment including depreciation, interest, insurance, and taxes were $139,680 per year for the small nursery. In addition there was $95,025 allocated for general overhead and $7,885 for interest on general overhead, insurance, and taxes, making a total of $242,590 total fixed costs for the small nursery (Table 2). These costs were divided equally among the five plant groups with each group receiving an assessment of $48,517 (Table 3). It was felt that the most reasonable way of assigning fixed costs is by area rather than plant. Once the physical facility is provided, fixed costs are incurred at essentially the same amount regardless of how the nursery facility is used. On a per-salable-plant basis, there was a considerable difference in annual fixed costs when they were differentiated by plant group (Table 4). In the small nursery,

hey were: $1.90 for group I (*Juniperus*), $2.34 for group I (*Cotoneaster*), $2.42 for group III (*Taxus*), $3.00 for roup IV (*Viburnum*), and $3.72 for group V (*Rhodo-endron*). The average over all groups was $2.53. nnual fixed costs for group V were more than double hose for group I. These costs were proportionate to the umber of salable plants per annum produced in allo-ated space. Fixed costs as a percentage of total costs anged from 42% to 51% in the small nursery, averaging 6% across the five groups (Table 4).

For the large nursery, annual fixed costs associated with capital investment, depreciation, interest, insurance, and taxes were $228,526. An additional $150,000 was allocated for general overhead and $12,521 for interest on general overhead, insurance, and taxes, making a total of $391,047 annual fixed costs for the large nursery (Table 2a). Assessment per plant group was $78,209 (Table 3a). Annual fixed costs per salable plant were: $1.50 for group I, $1.89 for group II, $1.95 for group III, $2.42 for group IV, and $3.00 for group V,

TABLE 2. Annual Fixed Costs (Dollars) for a Small* Container Nursery in Ohio, 1982.

| Item | Description | Depreciation** | Interest*** | Insurance and Taxes | Total |
|---|---|---|---|---|---|
| Land | Unimproved land | | 4,739 | 631 | 5,370 |
| + Improvements | Grading, tiling, graveling, pond | 8,571 | 25,713 | 3,428 | 37,712 |
| Subtotal | | 8,571 | 30,452 | 4,059 | 43,082 |
| Buildings | | | | | |
| Office and restrooms | 20′ x 40′ | 1,120 | 3,360 | 568 | 5,048 |
| Potting and packing shed | 40′ x 50′ | 1,800 | 5,400 | 913 | 8,113 |
| Machinery storage and shop | 40′ x 50′ | 1,800 | 5,400 | 913 | 8,113 |
| Polyhouse structures | 200′ x 20′ | 10,066 | 16,777 | 2,835 | 29,678 |
| Subtotal | | 14,786 | 30,937 | 5,229 | 50,952 |
| Machinery and Equipment | | | | | |
| Tractor, 60 HP | 60 HP, gas fuel w/front-end loader | 1,440 | 2,400 | 73 | 3,913 |
| Tractor, 28 HP | 28 HP, gas fuel | 1,085 | 1,808 | 55 | 2,948 |
| Manure spreader | 130 bu capacity | 192 | 320 | 10 | 522 |
| Wagon | 4-wheel | 414 | 690 | 21 | 1,125 |
| Irrigation pump/well | 75 HP, electric pump | 1,804 | 6,013 | 182 | 7,999 |
| Inground irrigation system | PVC pipe/sprinklers | 1,940 | 5,820 | 176 | 7,936 |
| Above ground irrigation system | PVC pipe/sprinklers | 3,489 | 2,908 | 88 | 6,485 |
| Fertilizer injector | 200 gal injector | 1,170 | 975 | 30 | 2,175 |
| Airblast sprayer | 300 gal, on trailer | 894 | 1,043 | 36 | 1,973 |
| Forklift | 3,000 lb lift, exterior-use wheels | 2,160 | 3,600 | 109 | 5,869 |
| Truck | 1/2 ton pickup | 1,440 | 1,200 | 36 | 2,676 |
| Pallets | Wooden | 1,047 | 628 | | 1,675 |
| Handtools | Miscellaneous | 200 | 150 | | 350 |
| Subtotal | | 17,275 | 27,555 | 816 | 45,646 |
| General Overhead | | | | | |
| Utilities | Telephone, electric, gas heat | | | | 5,325 |
| Licenses and bonds | | | | | 375 |
| General repairs and maintenance | Buildings, grounds | | | | 6,140 |
| Advertising and printing | | | | | 1,050 |
| Insurance, personnel | Workmen's comp., FICA, health, unemp. | | | | 19,060 |
| Travel and other | | | | | 1,500 |
| Professional fees | | | | | 75 |
| Administrative and Management | Clerical, operator, supervisory, labor and office supplies | | | | 60,500 |
| Miscellaneous | | | | | 1,000 |
| Subtotal | | | | | 95,025 |
| Interest on General Overhead, Insurance, and Taxes | Compounded at 15% per annum for 6 months | | | | 7,885 |
| Total Annual Fixed Costs | | | | | 242,590 |

*17.04 acres, 340,000 sq ft growing space, 204,000 sq ft of polyhouse space.
**Depreciation was estimated by dividing initial cost adjusted for salvage value, by the years of useful life.
***Interest costs were estimated by multiplying the initial value of land, building, equipment and machinery by the interest rate, 15% per annum.

averaging $2.04 over all groups (Table 4a). Fixed costs as a percent of total costs were lower than for the small nursery, ranging from 37% to 46% and averaging 42% across groups (Table 4a). This lower percentage was associated with the lower capital requirement per salable plant capacity.

Annual fixed costs per salable plant were substantially lower for the large nursery compared to the small. For group I the difference was $0.40, for group II $0.45, for group III $0.47, for group IV $0.58, and for group V $0.72, averaging $0.49 across groups. This approximate 25% gain in efficiency when going from the small to the large nursery is attributable to the more efficient use of buildings, machinery, and equipment of the large nursery over the small.

Nurserymen having established facilities might well consider annual fixed costs to be lower than those reported here. This is especially true if they compute

TABLE 2a. Annual Fixed Costs (Dollars) for a Large* Container Nursery in Ohio , 1982

| Item | Description | Depreciation** | Interest*** | Insurance and Taxes | Total |
|---|---|---|---|---|---|
| Land | Unimproved land | | 9,169 | 1,223 | 10,392 |
| + Improvements | Grading, tiling, graveling, pond | 16,315 | 48,946 | 6,526 | 71,787 |
| Subtotal | | 16,315 | 58,115 | 7,749 | 82,179 |
| Buildings | | | | | |
| Office and restrooms | 20′ x 40′ | 1,120 | 3,360 | 568 | 5,048 |
| Potting and packing shed | 40′ x 50′ | 1,800 | 5,400 | 913 | 8,113 |
| Machinery storage and shop | 40′ x 50′ | 1,800 | 5,400 | 913 | 8,113 |
| Polyhouse structures | 200′ x 20′ | 20,134 | 33,556 | 5,671 | 59,361 |
| Subtotal | | 24,854 | 47,716 | 8,065 | 80,635 |
| Machinery and Equipment | | | | | |
| Tractor, 60 HP | 60 HP, gas fuel w/front-end loader | 1,440 | 2,400 | 73 | 3,913 |
| Tractor, 28 HP | 28 HP, gas fuel | 1,085 | 1,808 | 55 | 2,948 |
| Manure spreader | 130 bu capacity | 192 | 320 | 10 | 522 |
| Wagon | 4-wheel | 828 | 1,380 | 42 | 2,250 |
| Irrigation pump/well | 75 HP, electric pump | 1,804 | 6,013 | 182 | 7,999 |
| Inground irrigation system | PVC pipe/sprinklers | 3,858 | 11,574 | 350 | 15,782 |
| Above ground irrigation system | PVC pipe/sprinklers | 6,978 | 5,815 | 176 | 12,969 |
| Fertilizer injector | 200 gal injector | 1,170 | 975 | 30 | 2,175 |
| Airblast sprayer | 300 gal, on trailer | 894 | 1,043 | 36 | 1,973 |
| Forklift | 3,000 lb lift, exterior-use wheels | 2,160 | 3,600 | 109 | 5,869 |
| Truck | 1/2 ton pickup | 2,880 | 2,400 | 73 | 5,353 |
| Pallets | Wooden | 2,037 | 1,222 | | 3,259 |
| Handtools | Miscellaneous | 400 | 300 | | 700 |
| Subtotal | | 25,726 | 38,850 | 1,136 | 65,712 |
| General Overhead | | | | | |
| Utilities | Telephone, electric, gas heat | | | | 7,990 |
| Licenses and bonds | | | | | 565 |
| General repairs and maintenance | Buildings, grounds | | | | 10,585 |
| Advertising and printing | | | | | 1,575 |
| Insurance, personnel | Workmen's comp., FICA, health, unemp. | | | | 31,420 |
| Travel and other | | | | | 2,250 |
| Professional fees | | | | | 115 |
| Administrative and managemeent | Clerical, operator, supervisory, labor and office supplies | | | | 93,500 |
| Miscellaneous | | | | | 2,000 |
| Subtotal | | | | | 150,000 |
| Interest on General Overhead, Insurance, and Taxes | Compounded at 15% per annum for 6 months | | | | 12,521 |
| Total Annual Fixed Costs | | | | | 391,047 |

*17.04 acres, 340,000 sq ft growing space, 204,000 sq ft of polyhouse space.
**Depreciation was estimated by dividing initial cost adjusted for salvage value, by the years of useful life.
***Interest costs were estimated by multiplying the initial value of land, building, equipment and machinery by the interest rate, 15% per annum.

depreciation and repairs on the original value of land improvements, buildings, machinery, and equipment and if they place a low value on their own management input. Good management, for planning purposes, however, dictates computing depreciation and repairs on replacement value rather than cost. It also dictates placing a value on managerial time that would be comparable to salaries paid in competitive firms.

When annual fixed costs were compared to total annual costs on a per-salable-plant basis, it was determined that they ranged from 37% to 51% of total costs depending upon size of firm and species of plant (Tables 4 and 4a). While this might seem high to many nurserymen and/or others concerned with the industry, these percentages would be in line with those for similar industries when considering new facilities. Brumfield, *et al.* (2), in a synthesized analyses of overhead costs of greenhouse firms, found fixed (overhead) costs as a percent of sales to range from about 45% to more than 67% depending on size of firm and market channel. The values of this study are not directly comparable with Brumfield *et al.* (percent total costs vs. percent of sales); however, if marketing costs and potential profit were taken into account so that a direct comparison could be made, the fixed costs from the Brumfield study would be considerably higher as a percent of total costs than were reported in these analyses.

## SUMMARY AND IMPLICATIONS

Annual fixed costs per salable plant in the small nursery ranged from $1.90 to $3.72, averaging $2.53. In the large nursery comparable costs were $1.50, $3.00, and $2.04. This approximate 25% gain in efficiency when going from the small to the large nursery is attributable to the more efficient use of buildings, machinery, and equipment of the large nursery over the small. Fixed costs as a percentage of total costs in the small nursery ranged from 42% to 51%, averaging 46% across species. Comparable values for the large nursery were 37%, 46%, and 42%. Differences in fixed costs between plant species were totally determined by space requirements for production.

When total annual costs per salable plant are considered, with fixed costs making up from 37% to 51% of the total, a comparison with prices in Ohio producers' wholesale catalogs would undoubtedly show, in a great

TABLE 3.--Summary of Annual Fixed Costs (Dollars) of Operating a Small* Container Nursery in Ohio, 1982

| Item | Group I (Juniper) | Group II (Contoneaster) | Group III (Taxus) | Group IV (Viburnum) | Group V (Rhododendron) | Total |
|---|---|---|---|---|---|---|
| Fixed Cost | | | | | | |
| Land and improvements | 8,616 | 8,616 | 8,616 | 8,616 | 8,616 | 43,080 |
| Buildings | 10,190 | 10,190 | 10,190 | 10,190 | 10,190 | 50,950 |
| Machinery and equipment | 9,129 | 9,129 | 9,129 | 9,129 | 9,129 | 45,645 |
| General overhead | 19,005 | 19,005 | 19,005 | 19,005 | 19,005 | 95,025 |
| Interest on general overhead, isurance, and taxes | 1,577 | 1,577 | 1,577 | 1,577 | 1,577 | 7,885 |
| TOTAL | 48,517 | 48,517 | 48,517 | 48,517 | 48,517 | 242,585 |
| Salable Plants per Year | 25,600 | 20,730 | 20,085 | 16,185 | 13,050 | 95,650 |
| Annual Fixed Cost per Salable Plant | 1.90 | 2.34 | 2.42 | 3.00 | 3.72 | 2.53 |

*17.04 Acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space

TABLE 3a.--Summary of Annual Fixed Costs (Dollars) of Operating a Large* Container Nursery in Ohio, 1982

| Item | Group I (Juniper) | Group II (Contoneaster) | Group III (Taxus) | Group IV (Viburnum) | Group V (Rhododendron) | Total |
|---|---|---|---|---|---|---|
| Fixed Cost | | | | | | |
| Land and improvements | 16,436 | 16,436 | 16,436 | 16,436 | 16,436 | 82,180 |
| Buildings | 16,127 | 16,127 | 16,127 | 16,127 | 16,127 | 80,635 |
| Machinery and equipment | 13,142 | 13,142 | 13,142 | 13,142 | 13,142 | 65,710 |
| General overhead | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 150,000 |
| Interest on general overhead, isurance, and taxes | 2,504 | 2,504 | 2,504 | 2,405 | 2,504 | 12,520 |
| TOTAL | 78,209 | 78,209 | 78,209 | 78,209 | 78,209 | 391,045 |
| Salable Plants per Year | 52,000 | 41,455 | 40,165 | 32,380 | 26,095 | 192,095 |
| Annual Fixed Cost per Salable Plant | 1.50 | 1.89 | 1.95 | 2.42 | 3.00 | 2.04 |

*33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space

TABLE 4.--Summary of Annual Fixed, Variable, and Total Costs (Dollars) per Salable Plant of Operating a Small Container Nursery in Ohio, 1982.

| Item | Group I (Juniper) | | Group II (Cotoneaster) | | Group III (Taxus) | | Group IV (Viburnum) | | Group V (Rhododendron) | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost |
| Fixed Cost Items | | | | | | | | | | | | |
| Land and Improvements | .34 | ( 8) | .41 | ( 8) | .43 | ( 8) | .53 | ( 9) | .66 | ( 9) | .45 | ( 8) |
| Buildings | .40 | ( 9) | .49 | (10) | .51 | ( 9) | .63 | (11) | .78 | (11) | .53 | (10) |
| Machinery and Equipment | .36 | ( 8) | .44 | ( 8) | .45 | ( 8) | .56 | ( 9) | .70 | ( 9) | .48 | ( 9) |
| General Overhead | .74 | (16) | .92 | (18) | .95 | (17) | 1.18 | (20) | 1.46 | (20) | .99 | (18) |
| Interest on General Overhead, Insurance, and Taxes | .06 | ( 1) | .08 | ( 2) | .08 | ( 1) | .10 | ( 2) | .12 | ( 2) | .08 | ( 1) |
| Total Annual Fixed Costs | 1.90 | (42) | 2.34 | (46) | 2.42 | (43) | 3.00 | (51) | 3.72 | (51) | 2.53 | (46) |
| Total Annual Variable Costs | 2.60 | (58) | 2.70 | (54) | 3.16 | (57) | 2.84 | (49) | 3.64 | (49) | 2.93 | (54) |
| Total Annual costs | 4.50 | (100) | 5.04 | (100) | 5.58 | (100) | 5.84 | (100) | 7.36 | (100) | 5.46 | (100) |

*17.04 acres, 340,000 sq ft of growing space , 204,000 sq ft of polyhouse space

TABLE 4a.--Summary of Annual Fixed, Variable, and Total Costs (Dollars) per Salable Plant of Operating a Large Container Nursery in Ohio, 1982

| Item | Group I (Juniper) | | Group II (Cotoneaster) | | Group III (Taxus) | | Group IV (Viburnum) | | Group V (Rhododendron) | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost |
| Fixed Cost Items | | | | | | | | | | | | |
| Land and Improvements | .31 | ( 8) | .40 | ( 9) | .41 | ( 8) | .51 | (10) | .63 | (10) | .43 | ( 9) |
| Buildings | .31 | ( 8) | .39 | ( 9) | .40 | ( 8) | .50 | ( 9) | .62 | ( 9) | .42 | ( 9) |
| Machinery and Equipment | .25 | ( 6) | .32 | ( 7) | .33 | ( 6) | .41 | ( 8) | .50 | ( 8) | .34 | ( 7) |
| General Overhead | .58 | (14) | .72 | (16) | .75 | (15) | .92 | (18) | 1.15 | (17) | .78 | (16) |
| Interest on General Overhead, Insurance, and Taxes | .05 | ( 1) | .06 | ( 1) | .06 | ( 1) | .08 | ( 1) | .10 | ( 2) | .07 | ( 1) |
| Total Annual Fixed Costs | 1.50 | (37) | 1.89 | (42) | 1.95 | (38) | 2.42 | (46) | 3.00 | (46) | 2.04 | (42) |
| Total Annual Variable Costs | 2.57 | (63) | 2.67 | (58) | 3.13 | (62) | 2.80 | (54) | 3.60 | (54) | 2.88 | (58) |
| Total Annual costs | 4.07 | (100) | 4.56 | (100) | 5.08 | (100) | 5.22 | (100) | 6.59 | (100) | 4.92 | (100) |

*33.04 acres, 680,000 sq ft of growing space , 408,000 sq ft of polyhouse space.

many cases, selling prices lower than total annual costs. In fact, if one were to add costs of selling, very few producers would presently be charging enough to cover all costs, let alone yield profits. How then can producers continue to operate? The answer lies in how producers both experience and figure costs. We have used the economic or accounting method which includes both explicit and implicit costs. Annual fixed costs, to a large degree, are implicit and often difficult to determine, such as the cost of equity capital and managerial capacities. The way these costs are determined varies significantly from firm to firm. Well-established nurseries are usually very accurate in determining explicit costs (usually variable such as containers, liners, fertilizer, labor, etc.), but often do not consider all implicit costs. They base their costs on "cash flow" and profit and loss on "tax accounting". These established nurseries, having purchased land at low cost, working with depreciated equipment, and often assigning low if any value to their management, would determine their annual fixed costs at a much lower level than presented in this article. However, if one were to start a new container nursery on a "normal" Ohio site, costs would probably be very close to those presented here.

For the industry, selling nursery products far below "accounting costs" implies that well-established nurseries, operating essentially debt free, would have strong staying power, whereas those who have just started or are heavily in debt may not be able to survive, especially if they are relying on their container operation to meet all overhead expenses. Second, starting a container nursery in Ohio would probably not prove profitable unless items such as buildings, equipment, machinery, and management could be shared with other enterprises or unless selling prices of nursery products in Ohio increased substantially. At current prices for nursery products, this study shows that the return on investment for establishing new, independently operating, container nurseries in Ohio would be marginal if not negative.

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# Annual Costs of Producing Spreading Deciduous Shrubs (*Cotoneaster*) Differentiated by Size of Firm in Ohio

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## ABSTRACT

The objective of this study was to determine annual production costs for spreading deciduous shrubs in containers in Ohio differentiated by size of firm. This objective was accomplished by synthesizing two model container nurseries using the conceptual framework of economic engineering. Once the nurseries were synthesized, growing space was divided into five equal parts with each part being assigned a plant group. In the small container nursery, spreading deciduous shrubs were allocated 68,000 sq ft of growing space and 40,800 sq ft of polyhouse space. For the large nursery, the figures were 136,000 and 81,600 sq ft, respectively. One specific species of spreading deciduous shrub, *Cotoneaster,* was chosen for detailed analysis. In the space allocated, 20,730 12-15 inch salable cotoneaster plants could be produced annually in the small nursery and 41,455 in the large. Total annual costs per salable plant were $5.04 in the small nursery and $4.56 in the large. These costs were based on 1982 figures and assumed a 2-year growing cycle with production in 2-gallon containers.

## INTRODUCTION

Spreading deciduous shrubs including various species of *Berberis, Cotoneaster,* and *Euonymus* are important plants in Ohio container nursery production. *Berberis t.* 'Crimson Pygmy', for example, is a dwarf, compact, red-leaf plant that makes an attractive hedge or accent plant. *Cotoneaster apiculata* has a low growth habit, attractive pink flowers in the Spring, and bright red berries in the Autumn that make it a very desirable deciduous ground cover. *Euonymus alatus* 'Compacta', a low growing shrub, has small green leaves in Summer and outstanding red foliage in Autumn. All of these plants are hardy once established, but require considerable overwinter protection in the nursery when produced in containers.

The specific objective of this study was to determine annual production costs for spreading deciduous shrubs in containers in Ohio differentiated by size of firm. This information should aid Ohio nurserymen in their decisions regarding which plants to grow and in what quantities.

## MATERIALS AND METHODS

In the study, two model firms were synthesized using the conceptual framework of economic engineering wherein the 'best proven practice' was included in each model. They were synthesized based on the Columbus, Ohio, area. The complete synthesis included developing an appropriate production cycle; schematic drawings of the physical layout, including buildings and irrigation system; lists of equipment and other items; a complete sequence by month and year of nursery operational steps beginning with the purchase of plant liners and ending with loading the finished product for wholesale distribution; and budgets for fixed and variable costs (3).

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during 1982. The basic goals in synthesizing the production facilities were to minimize labor expenses, flow and movement of plant material and equipment, water runoff, and initial investment, and to maximize the number of salable plants and keep future expansion possible. See Taylor *et al.* (3) for a detailed analysis of the physical plant, production system, and capital and production budgets.[2] Kneen *et al.* (1) provide a rather precise summary of capital requirements for establishing container nurseries in Ohio.

The production system chosen for this analysis consists of utilizing husky 2-year-old bareroot liners to produce a salable plant within two growing seasons. These 6-7" liners are transplanted directly into 2-gallon (8-½" x 8") copolymer containers during the month of May. Approximately 10% of the crop will be sold during the fall of the second growing season (approximately 18 months), 65% during March and April after the second growing season (approximately 22-23 months), and 25% during May after the second growing season (24 months). May is a period when clean-up sales are being made and new plants started. This production system saves transplanting as the plants are sold in the same containers in which they are started (2 gallon).

A model facility was synthesized for both a small (340,000 sq ft of growing area) and a large (680,000 sq ft of growing area) container nursery. The nursery operations were assumed to produce a diverse line of nursery stock each having a 2-year production cycle. Commonly grown nursery stock was divided into five cultural groups. While not all inclusive, the groups do permit developing a range of per unit costs related to input costs and cultural factors. For analytical purposes, it was assumed that each cultural group would occupy 20% of the growing area (*i.e.*, small nursery = 68,000 sq ft per group; large nursery = 136,000 sq ft per group). Costs developed on spreading deciduous shrubs (*Cotoneaster*) therefore were based on the scale of complete

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nursery, but analyzed on the basis of percent of total space occupied. A report on spreading evergreens (*Juniperus*) using equivalent 1982 data was previously published (2), while companion studies in this publication report on slow growing evergreens (page 45), upright deciduous shrubs (page 50), and broadleaf evergreens (page 55).

For detailed analysis on spreading deciduous shrubs, one specific plant type (*Cotoneaster*) was chosen. While it is recognized that other spreading deciduous shrubs would have somewhat different requirements, it was felt that the requirements would not vary significantly in cost from the cotoneasters analyzed. Among others, the category of spreading deciduous shrubs would include *Berberis t.* 'Crimson Pygmy', *Cotoneaster apiculata, Cotoneaster horizontalis, Cotoneaster dammerii,* and *Euonymus alatus* 'Compacta'. Some of their unique cultural characteristics would be hardwood bark medium and need for maximum overwinter protection.

Costs were established for all factors of production including management and invested capital. In economic terms, costs associated with factors of production inputted by owner/operators are often referred to as 'opportunity costs' or the income these factors could have received if they were employed elsewhere. For example, owners could usually be employed as managers at other nurseries, and money invested in land, buildings, irrigation systems, and equipment could have earned interest if it had been placed in financial institutions.

Capital requirements for establishing the nurseries were first determined (1). Second, capital requirements per salable plant capacity by spacing and size of nursery were established (3). Third, annual fixed costs were calculated (see page 31). Fourth, annual variable costs were determined for each of the two sized nurseries (Tables 1-3). Fifth, summaries were made for annual fixed and variable costs for each of the plant groups according to size of nursery (Table 4). This allowed cost comparisons based on size of nursery.

Most nurseries use cash rather than accrual accounting procedures. For this reason, the analyses were completed on a "cash" basis. Analyses on a cash basis does not give a true economic picture of the cost of producing a plant as it does not take into account the time value of money from the time the plant is planted until it is harvested. The analyses do, however, give a true estimate of the annual cost per salable plant.

Total annual production costs consist of both fixed and variable factors. Fixed costs are primarily made up of implicit costs such as depreciation on buildings and equipment, interest charges (both for borrowed and equity capital), and charges for management. Many nurserymen do not adequately consider fixed costs when computing costs of production. Fixed items are often considered as residual claimants on income. For example, management is compensated if all other factors of production have been accounted for. As noted previously, annual fixed costs are discussed in greater detail in a companion article.

## Variable Costs

Variable costs include all cost factors that vary with the quantity of plants being grown at one point in time. Variable costs are explicit, obvious, and normally paid out yearly. An example of variable costs is the number of liners required for spring planting which depends upon the quantity of plants management desires to have in inventory plus planting losses. A loss factor of 5% was assumed, with 2½% being taken in the first production year and 2½% in the second. Variable costs were subdivided into the following categories: materials, machinery and equipment, labor, and interest on operating capital (Tables 1 and 2).

**Containers.** Container cost was the price of #2 containers plus freight which was estimated at 10%.

**Soil mixture.** A wide variety of growing media is used by nursery producers. While materials budgeted here would provide a good media for the plants under consideration, many producers may prefer a somewhat different mixture. Costs involved are for basic ingredients (sand, hardwood bark, soil, vermiculite, haydite, peatmoss), any added micro-elements, chemical additives for bark composting, fertilizers, and freight. All labor and equipment used in mixing or transferring to potting locations is included under labor hours and variable equipment and machinery costs.

**Liners.** Two costs compose the total for liners. The major cost is the purchase price. While price is somewhat dependent upon quality and quantity, it was assumed that sufficient quality units would be ordered in either sized nursery to obtain them at the lowest possible cost. The second cost was for packing and shipping the liner from producer to purchaser. This was estimated at 10% of the purchase price. The size of liner purchased took into account the objective that each plant was to be grown in a 2-gallon container for two full growing seasons without becoming pot bound or over grown.

**Polyethylene film.** The cost of the film delivered to the nursery.

**Thermal blankets.** Thermal blankets were provided for overwintering and were used in lieu of supplemental heat. Due to the cost of energy, supplementary heat is being phased out in Ohio. It was anticipated that the thermal blankets would be used for three seasons. An individual nurseryman could cut costs in this category if he could use the thermal blankets for additional seasons. Their costs were based upon the delivered price.

**Strip tags.** Strip tags are provided for identifying plants by botanical name, common name, state where plant was grown, and nursery producer. Costs include printing and shipping charges.

**Chemicals.** Chemical costs were subdivided into three cultural programs. The first is the herbicide, the cost of which is the purchase price of the various pre-emergence and post-emergence materials. The second combines insecticide/miticide/fungicides used to control insect, mite, and disease problems. Purchase price reflects total cost for the chemicals as local distributors were assumed. The third is fertilizer. For container op-

erations, the purchase price from local suppliers of both soluble and slow-release fertilizers reflects total cost.

**Machinery and equipment.** Variable machinery and equipment costs represent all costs incurred while equipment or machinery is in use. These costs are comprised of repair, fuel, and lubrication/filter (Table 3). Repair cost per hour was calculated by multiplying initial cost by a stated repair percentage divided by the estimated lifetime use of the machinery in the large nursery in hours. The same repair cost per hour was used for both sized nurseries. Fuel costs were determined by multiplying units of fuel used per hour by the price per unit. Filter/lubrication cost was estimated at a constant factor of 15% of calculated fuel cost. Summation of repair, fuel, and filter/lubrication costs results in total variable costs per hour of machinery or equipment usage. These costs were divided equally between the five plant groups making up the two nurseries.

TABLE 1.--Annual Variable Costs (Dollars) for Spreading Deciduous Shrubs (Cotoneaster) for a Small* Container Nursery in Ohio, 1982.

| Item | Description | Unit | Cost per Unit | Quantity | Total Variable Cost |
|---|---|---|---|---|---|
| Materials | | | | | |
| Container | #2, 8 1/2" x 8" copolymer propylene | each | 0.29 | 21,820.00 | 6,328 |
| Soil mixture | Hardwood bark, sand, nutrients | cu yd | 31.00 | 174.56 | 5,411 |
| Liners | 2-year 6-7" liner | each | .85 | 21,820.00 | 18,547 |
| Polyethylene film | 4 mil white, 32' x 225' | each | 107.00 | 10.20 | 1,091 |
| Thermal blanket | 4 - 1/4" 80" x 225' per house | each | 775.00 | 1/3 (10.20)** | 2,635 |
| Strip tags | 5/8" x 7" plastic strip tag | each | .02 | 20,730.00 | 415 |
| Chemicals | Oxadiazon 4G (Ronstar) (herbicide) | pound | .90 | 292.00 | 263 |
| | Benomyl 50 WP (Benlate) (fungicide) | pound | 10.00 | 6.00 | 60 |
| | Demetron 6 (Metra-Systox-M) (insecticide) | ounces | .71 | 52.00 | 37 |
| | Cyhexatin 50WP (Kelthane) (miticide) | pound | 22.25 | 1.50 | 33 |
| | Chlorothalonil 10M cu ft (Termil) (fungicide) | canister | 1.90 | 60.20 | 114 |
| | Osmocote 8-9 mo (18-6-12) | pound | .86 | 3,425.58 | 2,946 |
| | Urea 45-0-0 (fertilizer) | pound | .13 | 2,628.40 | 342 |
| | Glyphosate (Roundup) (herbicide) | quart | 16.60 | 2.80 | 46 |
| Subtotal | | | | | 38,268 |
| Machinery and Equipment | | | | | |
| | Tractor, 60 HP | hour | 15.85 | 26.60 | 422 |
| | Tractor, 28 HP | hour | 4.92 | 103.40 | 509 |
| | Manure spreader, 130 bu | hour | 1.58 | 8.60 | 14 |
| | Wagon, 4-wheel | hour | 0.53 | 155.60 | 82 |
| | Irrigation/well, pump 75 HP | hour | 6.65 | 147.00 | 978 |
| | Inground irrigation system | hour | 1.54 | 147.00 | 226 |
| | Above ground irrigation system | hour | 3.09 | 147.00 | 454 |
| | Fertilizer injector | hour | 4.33 | 24.00 | 104 |
| | Airblast sprayer | hour | 23.98 | 3.20 | 77 |
| | Forklift | hour | 6.59 | 26.00 | 171 |
| | 1/2 ton pick-up truck | hour | 8.51 | 75.00 | 638 |
| Subtotal | | | | | 3,675 |
| Labor | | | | | |
| | Labor hours | hour | 5.15*** | 1,622.00 | 8,353 |
| | Related labor hours | hour | 5.15 | 324.40 | 1,671 |
| Subtotal | | | | | 10,024 |
| Interest Charge on Operating Capital | Computed at 15% on an annual basis for 6 months | percent | 7.5 (0.075) | 53,868.00 | 4,040 |
| Total Annual Variable Costs | | | | | 56,007 |
| Annual Variable Cost per 12-15 Inch Salable Plant | | | | | 2.70 |

*Total Nursery - 17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space.
Spreading Deciduous Shrubs, 68,000 sq ft of growing space, 40,800 sq ft of polyhouse space, 20,730 12-15 inch salable plants per year.

**Thermal blankets would be used for three seasons.

***Average basic wage before withholding taxes and fringes $4.30, taxes and fringes add 19.84% or $0.85 for a total of $5.15.

**Hourly labor.** The following were included in determining total hourly labor charges: basic average hourly rate ($4.30), social security tax "FICA" (6.13% of basis), workmen's compensation (2.71% of basis), general health insurance (3.50% of basis), holiday and vacation pay (4.00% of basis), and unemployment insurance (3.4% for first $6,000 of a person's pay). The total hourly wage including all factors was budgeted at $5.15 per hour. Each major production activity was allocated necessary labor hours to accomplish assigned tasks. Since labor use was dependent upon the number of units produced, they were lower for those plant groups having the fewest number of salable plants.

## Cost Summaries

After all cost factors were determined, they were summarized based upon cost per salable plant by size of nursery.

TABLE 2.--Annual Variable Costs (Dollars) for Spreading Deciduous Shrubs (Cotoneaster) for a Large* Container Nursery in Ohio, 1982.

| Item | Description | Unit | Cost per Unit | Quantity | Total Variable Cost |
|---|---|---|---|---|---|
| Materials | | | | | |
| Container | #2, 8 1/2" x 8" copolymer propylene | each | 0.29 | 46,635.00 | 12,654 |
| Soil mixture | Hardwood bark, sand, nutrients | cu yd | 31.00 | 347.08 | 10,760 |
| Liners | 2-year 6-7" liner | each | .85 | 43,635.00 | 31,090 |
| Polyethylene film | 4 mil white, 32' x 225' | each | 107.00 | 20.40 | 2,183 |
| Thermal blanket | 4 - 1/4" 80" x 225' per house | each | 775.00 | 1/3 (20.40)** | 5,270 |
| Strip tags | 5/8" x 7" plastic strip tag | each | .02 | 41,455.00 | 829 |
| Chemicals | Oxadiazon 4G (Ronstar) (herbicide) | pound | .90 | 597.00 | 537 |
| | Benomyl 50 WP (Benlate) (fungicide) | pound | 10.00 | 12.40 | 124 |
| | Demetron 6 (Meta-Systox-M) (insecticide) | ounces | .71 | 106.00 | 75 |
| | Cyhexatin 50WP (Kelthane) (miticide) | pound | 22.25 | 3.20 | 71 |
| | Chlorothalonil 10M cu ft (Termil) (fungicide) | canister | 1.90 | 122.00 | 232 |
| | Osmocote 8-9 mo (18-6-12) | pound | .86 | 6,850.00 | 5,891 |
| | Urea 45-0-0 (fertilizer) | pound | .13 | 5,043.40 | 656 |
| | Glyphosate (herbicide) | quart | 16.60 | 5.90 | 93 |
| Subtotal | | | | | 76,465 |
| Machinery and Equipment | | | | | |
| | Tractor, 60 HP | hour | 15.85 | 54.00 | 856 |
| | Tractor, 28 HP | hour | 4.92 | 210.00 | 1,033 |
| | Manure spreader, 130 bu | hour | 1.58 | 17.40 | 27 |
| | Wagon, 4-wheel | hour | 0.53 | 316.00 | 167 |
| | Irrigation/well, pump 75 HP | hour | 6.65 | 200.40 | 1,333 |
| | Inground irrigation system | hour | 1.54 | 200.40 | 309 |
| | Above ground irrigation system | hour | 3.09 | 200.40 | 619 |
| | Fertilizer injector | hour | 4.33 | 36.00 | 156 |
| | Airblast sprayer | hour | 23.98 | 6.60 | 158 |
| | Forklift | hour | 6.59 | 52.80 | 348 |
| | 1/2 ton pick-up truck | hour | 8.51 | 150.00 | 1,276 |
| Subtotal | | | | | 6,282 |
| Labor | | | | | |
| | Labor hours | hour | 5.15*** | 3,245.00 | 16,712 |
| | Related labor hours | hour | 5.15 | 649.00 | 3,342 |
| Subtotal | | | | | 20,054 |
| Interest Charge on Operating Capital | Computed at 15% on an annual basis for 6 months | percent | 7.5 (0.075) | 106,597.00 | 7,995 |
| Total Annual Variable Costs | | | | | 110,796 |
| Annual Variable Cost per 12-15 Inch Salable Plant | | | | | 2.67 |

*Total Nursery - 33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space. Spreading Deciduous Shrubs, 136,000 sq ft of growing space, 81,600 sq ft of polyhouse space, 41,455 12-15 inch salable plants per year.

**Thermal blankets would be used for three seasons.

***Average basic wage before withholding taxes and fringes $4.30, taxes and fringes add 19.84% or $0.85 for a total of $5.15.

TABLE 3.--Estimated Variable Cost per Hour of Use for Machinery and Equipment for Container Nurseries in Ohio, 1982.

| Item Number | Item | New Cost (dollars) | Expected Life (years) | Estimated Annual Use: Small* Nursery (hours) | Estimated Annual Use: Large** Nursery (hours) | Estimated Cost per Hour of Use: Repairs*** (dollars) | Fuel**** (dollars) | Lubrication and Filter (dollars) | Total (dollars) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Tractor, 60 HP, front end loader | 16,000 | 10 | 132.70 | 269.50 | 5.34 | 9.14 | 1.37 | 15.85 |
| 2 | Tractor, 28 HP | 6,025 | 10 | 258.35 ea | 349.92 ea | 1.55 | 2.93 | 0.44 | 4.92 |
| 3 | Manure spreader, 130 bu. | 2,135 | 10 | 43.00 | 87.40 | 1.58 | | | 1.58 |
| 4 | Wagon, 4-wheel, self steer | 2,300 | 10 | 259.23 ea | 263.25 ea | 0.53 | | | 0.53 |
| 5 | Irrigation well & Pump-75 HP | 40,085 | 20 | 735.00 | 1,002.50 | 0.20 | 5.61 | 0.84 | 6.65 |
| 6 | Inground irrigation system***** | 77,160 | 20 | 735.00 | 1,002.50 | 1.54 | | | 1.54 |
| 7 | Above ground irrigation system***** | 38,765 | 5 | 735.00 | 1,002.50 | 3.09 | | | 3.09 |
| 8 | Fertilizer injector | 6,500 | 5 | 120.00 | 180.00 | 4.33 | | | 4.33 |
| 9 | Air blast sprayer | 6,995 | 7 | 16.20 | 33.15 | 23.98 | | | 23.98 |
| 10 | Cyclone spreader | 40 | - | 12.40 | 25.40 | | | | |
| 11 | Forklift | 24,000 | 10 | 129.84 | 264.00 | 5.45 | 0.99 | 0.15 | 6.59 |
| 12 | Truck, 1/2 ton pick-up | 8,000 | 5 | 375.00 | 375.00 ea | 3.84 | 4.06 | 0.61 | 8.51 |

*17.04 acres, 340,000 sq ft growing space, 204,000 sq ft of polyhouse space.

**33.04 acres, 680,000 sq ft growing space, 408,000 sq ft of polyhouse space.

***Repairs per hour were based on useage of the large nursery. They were computed on the basis of percent of new cost over the life of the asset. Percent factors used were: 90 for item numbers 1,2,and 12; 80 for item 9; 65 for item 3; 60 for items 4, 8, and 11; 40 for items 6 and 7; and 10 for item 5. The total was then divided by the estimated total number of hours the equipment would be used in the large nursery during the life of the asset.

****Fuel was estimated at $1.27 gallon for gasoline drived items, $0.27 per killowatt for electrical driven and $24.66 for L.P. tank gas.

*****Cost is for a large nursery on which variable costs per hour were based. Cost for the small nursery was lower.

Table 4.--Summary of Annual Fixed, Variable, and Total Costs (Dollars) of Producing Spreading Deciduous Shrubs (Cotoneaster) in Containers in Ohio, 1982.

| Item | Small Container Nursery*: Cost | Cost per Salable Plant | Percent of Total Cost | Large Container Nursery**: Cost | Cost per Salable Plant | Percent of Total Cost |
|---|---|---|---|---|---|---|
| Fixed Cost Items | | | | | | |
| Land and Improvements | 8,616 | .41 | 8 | 16,436 | .40 | 9 |
| Buildings | 10,190 | .49 | 10 | 16,127 | .39 | 9 |
| Machinery and Equipment | 9,129 | .44 | 8 | 13,142 | .32 | 7 |
| General Overhead | 19,005 | .92 | 18 | 30,000 | .72 | 16 |
| Interest on General Overhead, Insurance, and Taxes | 1,577 | .08 | 2 | 2,504 | .06 | 1 |
| Subtotal | 48,517 | 2.34 | 46 | 78,209 | 1.89 | 42 |
| Variable Cost Items | | | | | | |
| Materials | 38,268 | 1.85 | 37 | 76,465 | 1.85 | 41 |
| Machinery and Equipment | 3,675 | .18 | 4 | 6,282 | .15 | 3 |
| Labor | 10,024 | .48 | 9 | 20,054 | .48 | 10 |
| Interest on Operating Capital | 4,040 | .19 | 4 | 7,995 | .19 | 4 |
| Subtotal | 56,007 | 2.70 | 54 | 110.796 | 2.67 | 58 |
| Total Annual Costs | 104,524 | 5.04 | 100 | 189,005 | 4.56 | 100 |

*Total Nursery - 17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space.
Spreading Deciduous Shrubs, 68,000 sq ft of growing space, 40,800 sq ft of polyhouse space, 20,730 12-15 inch salable plants per year.

**Total Nursery - 33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space.
Spreading Deciduous Shrubs, 136,000 sq ft of growing space, 81,600 sq ft of polyhouse space, 41,455 12-15 inch salable plants per year.

## RESULTS AND DISCUSSION

Annual fixed, variable, and total production costs of producing spreading deciduous shrubs (*Cotoneaster*) in container nurseries in Ohio for 1982 are summarized in Table 4. In the small nursery, total annual costs were $104,524 or $5.04 per salable 12-15 inch plant. Fixed costs totaled $48,517 or $2.34 per plant and made up 46% of total costs. Based on percentage of total costs, land and improvements made up 8%, buildings 10%, machinery and equipment 8%, general overhead 18%, and interest on general overhead, insurance, and taxes 2%. Variable costs totaled $56,007 or $2.70 per plant and made up 54% of total costs. Based on percentage of total costs, materials made up 37%, machinery and equipment 4%, labor 9%, and interest on operating capital 4%.

In the large nursery, total annual costs were $189,005 or $4.56 per salable 12-15 inch plant. Fixed costs totaled $78,209 or $1.89 per plant and made up 42% of total costs. Based on percentage of total costs, land and improvements made up 9%, buildings 9%, machinery and equipment 7%, general overhead 16%, and interest on general overhead, insurance, and taxes 1%. Variable costs totaled $110,796 or $2.67 per plant and made up 58% of total costs. Based on percentage of total costs, materials made up 41%, machinery and equipment 3%, labor 10%, and interest on operating capital 4%.

Total annual costs were 48 cents per plant more in the small nursery than in the large. Of this 48 cents, 45 cents or 94% were made up of fixed costs. On a per item basis, the large nursery's advantages were 1 cent on land and improvements, 10 cents on buildings, 12 cents on machinery and equipment, 20 cents on general overhead, and 2 cents on interest for general overhead, insurance, and taxes. The 3 cents for variable costs was all accounted for by machinery and equipment. Variable costs for materials, labor, and interest on operating capital were the same for both sized nurseries.

In the nurseries analyzed, it cost 11% less to produce a 12-15 inch salable spreading deciduous shrub (*Cotoneaster*) in the large nursery than in the small. While the overall reduction was 11%, it was 24% for fixed costs and only 1% for variable. Large-sized commercial container nurseries are able to make more efficient use of buildings, equipment, and machinery than small container nurseries.

Individual nurserymen might well experience or at least calculate costs considerably different than those depicted here. Most cost differences would probably be reflected in fixed rather than variable costs. Most fixed costs are implicit and their full impact may not be calculated by established nurserymen. Budgets presented assumed new facilities, machinery, and equipment. Most nurserymen have owned their land for many years and have used machinery and equipment. For the established nursery, budgeted fixed costs on land improvements, buildings, machinery, and equipment presented here would reflect replacement rather than 'book' value of depreciated items. Presented fixed costs also placed a market value on management. Many nurserymen place little if any value on their own management when computing costs. Variable items, on the other hand, are explicit, experienced at least yearly, and easily accounted for. Variable costs presented here would be typical for the industry in Ohio and should be rather consistent regardless of age and size of the nursery.

## SUMMARY

Total annual costs per salable spreading deciduous shrub (*Cotoneaster*) were $5.04 in the small nursery and $4.56 in the large. Fixed costs were $2.34 in the small nursery and $1.89 in the large for a differential of 45 cents per salable plant. Variable costs, on the other hand, were $2.70 in the small and $2.67 in the large for a differential of only 3 cents. These per plant costs assumed a 2-year growing cycle, production in 2-gallon containers, and an average size of 12-15 inches per salable plant.

These figures demonstrated that variable costs on a salable plant basis, at least over the size range of nurseries analyzed, remain reasonably constant. The small nursery could purchase materials and other variable items almost as cheaply as the large. Fixed costs, in contrast, changed significantly as size of nursery increased. This occurred because most of the fixed factors required to operate the small nursery such as management, buildings, and most machinery and equipment were also adequate to operate the large. As the size of nursery increased, costs for fixed items of production were spread over more salable units, thereby reducing the fixed cost per plant.

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# Annual Costs of Producing Slow-Growing Evergreens (*Taxus*) Differentiated by Size of Firm in Ohio

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## ABSTRACT

The objective of this study was to determine annual production costs for slow-growing evergreens in containers in Ohio differentiated by size of firm. This objective was accomplished by synthesizing two model container nurseries using the conceptual framework of economic engineering. Once the nurseries were synthesized, growing space was divided into five equal parts with each part being assigned a plant group. In the small container nursery, slow-growing evergreens were allocated 68,000 sq ft of growing space and 40,800 sq ft of polyhouse space. For the large nursery, the figures were 136,000 and 81,600 sq ft, respectively. One specific species of slow-growing evergreen (*Taxus*) was chosen for detailed analysis. In the space allocated, 20,085 12-15 inch salable *Taxus* could be produced annually in the small nursery and 40,165 in the large. Total annual costs per salable plant were $5.58 in the small nursery and $5.08 in the large. These costs were based on 1982 figures and assumed a 2-year growing cycle with production in 2-gallon containers.

## INTRODUCTION

Slow-growing evergreens, such as the various species of *Buxus and Taxus*, have long been planted for hedges, foundation plantings, and other locations where low maintenance is desirable. These plants have traditionally been grown in the field; however, new technological developments are now making it economically feasible to grow them in containers. These plants will probably in the future become as important to container operations as they have traditionally been in the field.

The specific objective of this study was to determine annual production costs for slow-growing evergreens in containers in Ohio differentiated by size of firm. This information should aid Ohio nurserymen in their decisions regarding which plants to grow and in what quantities.

## MATERIALS AND METHODS

In the study, two model firms were synthesized using the conceptual framework of economic engineering wherein the 'best proven practice' was included in each model. They were synthesized based on the Columbus, Ohio, area. The complete synthesis included developing an appropriate production cycle; schematic drawings of the physical layout, including buildings and irrigation systems; lists of equipment and other items; a complete sequence by month and year of nursery operational steps beginning with the purchase of plant liners and ending with loading the finished product for wholesale distribution; and budgets for fixed and variable costs (4).

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during 1982. The basic goals in synthesizing the production facilities were to minimize labor expenses, flow and movement of plant material and equipment, water runoff, and initial investment, and to maximize the number of salable plants and keep future expansion possible. See Taylor *et al.* (4) for a detailed analysis of the physical plant, production system, and capital production budgets.[2] Kneen *et al.* (1) provide a rather precise summary of capital requirements for establishing container nurseries in Ohio.

The production system chosen for this analysis essentially consists of utilizing husky 3-year-old bareroot liners to produce a salable plant within two growing seasons. These 6-7" liners are transplanted directly into 2-gallon (8½" x 8") copolymer containers during the month of May. Approximately 10% of the crop will be sold during the fall of the second growing season (approximately 18 months), 65% during March and April after the second growing season (approximately 22-23 months), and 25% during May after the second growing season (24 months). May is a period when clean-up sales are being made and new plants started. This production system saves transplanting as the plants are sold in the same containers in which they are started (2 gallon).

A model facility was synthesized for both a small (340,000 sq ft of growing area) and a large (680,000 sq ft of growing area) container nursery. The nursery operations were assumed to produce a diverse line of nursery stock each having a 2-year production cycle. Commonly grown nursery stock was divided into five cultural groups. While not all inclusive, the groups do permit a range of per unit costs to be developed as they relate to input costs and cultural factors. For analytical purposes, it was assumed that each cultural group would occupy 20% of the growing area (*i.e.*, small nursery = 68,000 sq ft per group; large nursery = 136,000 sq ft per group). Costs developed on slow-growing evergreens (*Taxus*) therefore were based on the scale of the complete nursery, but analyzed on the basis of percent of total space occupied. A report on spreading

[1]Graduate Student, Associate Professor, and Professor, Dept. of Agricultural Economics and Rural Sociology, and Professor, Dept. of Horticulture, respectively. Mr. Kneen is presently on the management staff at Studebaker Nurseries, Inc., New Carlisle, Ohio.

[2]A copy of this publication can be obtained by writing: Dr. Reed Taylor, The Ohio State University, 2120 Fyffe Road, Columbus, Ohio 43210.

evergreens (*Juniperus*) using equivalent 1982 data was previously published (2) while companion studies in this publication report on spreading deciduous shrubs (page 39), upright deciduous shrubs (page 50), and broadleaf evergreens (page 55).

For detailed analysis on slow-growing evergreens, one specific plant type (*Taxus*) was chosen. While it is recognized that other slow-growing evergreens would have somewhat different requirements, it was felt that the requirements would not vary significantly in cost from the *Taxus*. Among others, the category of slow-growing evergreens would include various species of *Buxus*. Some of their unique cultural characteristics would be pine bark medium and hardiness. They would require minimum overwinter protection. Thermal blankets within the polyhouses would not be required.

Costs were established for all factors of production including management and invested capital. In economic terms, costs associated with factors of production inputted by owner/operators are often referred to as 'opportunity costs' or the income these factors could have received if they were employed elsewhere. For example, owners could usually be employed as manag-

TABLE 1.--Annual Variable Costs (Dollars) for Slow Growing Evergreens (Taxus) for a Small* Container Nursery in Ohio, 1982.

| Item | Description | Unit | Cost per Unit | Quantity | Total Variable Cost |
|---|---|---|---|---|---|
| Materials | | | | | |
| Container | #2, 8 1/2" x 8" copolymer propylene | each | 0.29 | 21,140.00 | 6,131 |
| Soil mixture | Pine bark, sand, nutrients | cu yd | 33.00 | 169.20 | 5,584 |
| Liners | 3-year 6-7" liner | each | 1.25 | 21,140.00 | 26,425 |
| Polyethylene film | 4 mil white, 32' x 225' | each | 107.00 | 10.20 | 1,091 |
| Strip tags | 5/8" x 7" plastic strip tag | each | .02 | 20,085.00 | 402 |
| Chemicals | Oxadiazon 4G (Ronstar) (herbicide) | pound | .90 | 292.00 | 263 |
| | Benomyl 50 WP (Benlate) (fungicide) | pound | 10.00 | 6.00 | 60 |
| | Demetron 6 (Metra-Systox-M) (insecticide) | ounces | .71 | 52.00 | 37 |
| | Cyhexatin 50WP (Kelthane) (miticide) | pound | 22.25 | 1.50 | 33 |
| | Chlorothalonil 10M cu ft (Termil) (fungicide) | canister | 1.90 | 60.20 | 114 |
| | Lesco 3-4 mo (20-6-12)+Fe | pound | .80 | 5,707.80 | 4,566 |
| | Urea 45-0-0 (fertilizer) | pound | .13 | 2,628.40 | 342 |
| | Glyphosate (Roundup) (herbicide) | quart | 16.60 | 2.80 | 47 |
| Subtotal | | | | | 45,095 |
| Machinery and Equipment | | | | | |
| | Tractor, 60 HP | hour | 15.85 | 26.60 | 422 |
| | Tractor, 28 HP | hour | 4.92 | 103.40 | 509 |
| | Manure spreader, 130 bu | hour | 1.58 | 8.60 | 14 |
| | Wagon, 4-wheel | hour | 0.53 | 155.60 | 82 |
| | Irrigation/well, pump 75 HP | hour | 6.65 | 147.00 | 978 |
| | Inground irrigation system | hour | 1.54 | 147.00 | 226 |
| | Above ground irrigation system | hour | 3.09 | 147.00 | 454 |
| | Fertilizer injector | hour | 4.33 | 24.00 | 104 |
| | Airblast sprayer | hour | 23.98 | 3.20 | 77 |
| | Forklift | hour | 6.59 | 26.00 | 171 |
| | 1/2 ton pick-up truck | hour | 8.51 | 75.00 | 638 |
| Subtotal | | | | | 3,675 |
| Labor | | | | | |
| | Labor hours | hour | 5.15** | 1,673.00 | 8,616 |
| | Related labor hours | hour | 5.15 | 335.00 | 1,725 |
| Subtotal | | | | | 10,341 |
| Interest Charge on Operating Capital | Computed at 15% on an annual basis for 6 months | percent | 7.5 (0.075) | 58,996.00 | 4,425 |
| Total Annual Variable Costs | | | | | 63,536 |
| Annual Variable Cost per 12-15 Inch Salable Plant | | | | | 3.16 |

*Total Nursery - 17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space.
Slow Growing Evergreens, 68,000 sq ft of growing space, 40,800 sq ft of polyhouse space, 20,085 12-15 inch salable plants per year.

**Average basic wage before withholding taxes and fringes $4.30, taxes and fringes add 19.84% or $0.85 for a total of $5.15.

ers at other nurseries, and money invested in land, buildings, irrigation systems, and equipment could have earned interest if it had been placed in financial institutions.

Capital requirements for establishing the nurseries were first determined (1). Second, capital requirements per salable plant capacity by spacing and size of nursery were established (4). Third, annual fixed costs were calculated (see page 31). Fourth, annual variable costs were determined for each of the two sized nurseries (Tables 1 and 2). Fifth, summaries were made for annual fixed and variable costs for each of the plant groups according to size of nursery (Table 3). This allowed cost comparisons based on size of nursery.

Most nurseries use cash rather than accrual accounting procedures. For this reason, the analyses were completed on a "cash" basis. Analysis on a cash basis does not give a true economic picture of the cost of producing a plant as it does not take into account the time value of money from the time the plant is planted until it is harvested. The analyses do, however, give a true estimate of the annual cost per salable plant.

Total annual production costs consist of both fixed and variable factors. Fixed costs are primarily made up

TABLE 2.--Annual Variable Costs (Dollars) for Slow Growing Evergreens (Taxus) for a Large* Container Nursery in Ohio, 1982.

| Item | Description | Unit | Cost per Unit | Quantity | Total Variable Cost |
|---|---|---|---|---|---|
| Materials | | | | | |
| Container | #2, 8 1/2" x 8" copolymer propylene | each | 0.29 | 42,280.00 | 12,261 |
| Soil mixture | Pine bark, sand, nutrients | cu yd | 33.00 | 338.40 | 11,168 |
| Liners | 3-year 6-7" liner | each | 1.25 | 42,280.00 | 52,850 |
| Polyethylene film | 4 mil white, 32' x 225' | each | 107.00 | 20.40 | 2,183 |
| Strip tags | 5/8" x 7" plastic strip tag | each | .02 | 40,165.00 | 803 |
| Chemicals | Oxadiazon 4G (Ronstar) (herbicide) | pound | .90 | 597.00 | 537 |
| | Benomyl 50 WP (Benlate) (fungicide) | pound | 10.00 | 12.40 | 124 |
| | Demetron 6 (Meta-Systox-M) (insecticide) | ounces | .71 | 106.00 | 75 |
| | Cyhexatin 50WP (Kelthane) (miticide) | pound | 22.25 | 3.20 | 71 |
| | Chlorothalonil 10M cu ft (Termil) (fungicide) | canister | 1.90 | 122.00 | 232 |
| | Lesco 3-4 mo (20-6-12) | pound | .80 | 11,415.60 | 9,132 |
| | Urea 45-0-0 (fertilizer) | pound | .13 | 5,043.40 | 656 |
| | Glyphosate (Roundup) (herbicide) | quart | 16.60 | 5.60 | 93 |
| Subtotal | | | | | 90,185 |
| Machinery and Equipment | | | | | |
| | Tractor, 60 HP | hour | 15.85 | 54.00 | 856 |
| | Tractor, 28 HP | hour | 4.92 | 210.00 | 1,033 |
| | Manure spreader, 130 bu | hour | 1.58 | 17.40 | 27 |
| | Wagon, 4-wheel | hour | 0.53 | 316.00 | 167 |
| | Irrigation/well, pump 75 HP | hour | 6.65 | 200.40 | 1,333 |
| | Inground irrigation system | hour | 1.54 | 200.40 | 309 |
| | Above ground irrigation system | hour | 3.09 | 200.40 | 619 |
| | Fertilizer injector | hour | 4.33 | 36.00 | 156 |
| | Airblast sprayer | hour | 23.98 | 6.60 | 158 |
| | Forklift | hour | 6.59 | 52.80 | 348 |
| | 1/2 ton pick-up truck | hour | 8.51 | 150.00 | 1,276 |
| Subtotal | | | | | 6,282 |
| Labor | | | | | |
| | Labor hours | hour | 5.15** | 3,346.00 | 17,231 |
| | Related labor hours | hour | 5.15 | 669.00 | 3,445 |
| Subtotal | | | | | 20,676 |
| Interest Charge on Operating Capital | Computed at 15% on an annual basis for 6 months | percent | 7.5 (0.075) | 117,009.00 | 8,776 |
| Total Annual Variable Costs | | | | | 125,919 |
| Annual Variable Cost per 12-15 Inch Salable Plant | | | | | 3.14 |

*Total Nursery - 33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space.
Slow Growing Evergreens, 136,000 sq ft of growing space, 81,600 sq ft of polyhouse space, 40,165 12-15 inch salable plants per year.

**Average basic wage before withholding taxes and fringes $4.30, taxes and fringes add 19.84% or $0.85 for a total of $5.15.

of implicit costs such as depreciation on buildings and equipment, interest charges (both for borrowed and equity capital), and charges for management. Many nurserymen do not adequately consider fixed costs when computing costs of production. Fixed items are often considered as residual claimants on income. For example, management is compensated if all other factors of production have been accounted for. As noted previously, annual fixed costs are discussed in greater detail in a companion article.

Variable costs include all cost factors that vary with the quantity of plants being grown at one point in time. Variable costs are explicit, obvious, and normally paid out yearly. Variable costs were subdivided into the following categories: materials, machinery and equipment, labor, and interest on operating capital (Tables 1 and 2). Details on specific variable cost items are included in the companion article on spreading deciduous shrubs (page 39).

After all cost factors were determined, they were summarized based upon cost per salable plant by size of nursery.

## RESULTS AND DISCUSSION

Annual fixed, variable, and total production costs of producing slow-growing evergreens (*Taxus*) in container nurseries in Ohio for 1982 are summarized in Table 3. In the small nursery, total annual costs were $112,053 or $5.58 per salable 12-15 inch plant. Fixed costs totaled $48,517 or $2.42 per plant and made up 43% of total costs. Based on percentage of total costs, land and improvements made up 8%, buildings 9%, machinery and equipment 8%, general overhead 17%, and interest on general overhead, insurance, and taxes 1%. Variable costs totaled $63,536 or $3.16 per plant and made up 57% of total costs. Based on percentage of total costs, materials made up 40%, machinery and equipment 3%, labor 10%, and interest on operating capital 4%.

In the large nursery, total annual costs were $204,128 or $5.08 per salable 12-15 inch plant. Fixed costs totaled $78,109 or $1.95 per plant and made up 38% of total costs. Based on percentage of total costs, land and improvements made up 8%, buildings 8%, machinery and equipment 6%, general overhead 15%, and interest on general overhead, insurance, and taxes 1%. Variable costs totaled $125,919 or $3.13 per plant and made up 62% of total costs. Based on percentage of total costs, materials made up 44%, machinery and equipment 3%, labor 10%, and interest on operating capital 5%.

Total annual costs were 50 cents per plant more in the small nursery than in the large. Of this 50 cents, 47 cents or 94% were made up of fixed costs. On a per item basis, the large nursery's advantages were 2 cents on land and improvements, 11 cents on buildings, 12 cents on machinery and equipment, 20 cents on general overhead, and 2 cents on interest for general overhead, insurance, and taxes. The 3 cents accounted for by variable costs were 2 cents on machinery and equipment and 1

Table 3.--Summary of Annual Fixed, Variable, and Total Costs (Dollars) of Producing Slow Growing Evergreens (Taxus) in Containers in Ohio, 1982.

| | Small Container Nursery* | | | Large Container Nursery** | | |
|---|---|---|---|---|---|---|
| Item | Cost | Cost per Salable Plant | Percent of Total Cost | Cost | Cost per Salable Plant | Percent of Total Cost |
| Fixed Cost Items | | | | | | |
| Land and Improvements | 8,616 | .43 | 8 | 16,436 | .41 | 8 |
| Buildings | 10,190 | .51 | 9 | 16,127 | .40 | 8 |
| Machinery and Equipment | 9,129 | .45 | 8 | 13,142 | .33 | 6 |
| General Overhead | 19,005 | .95 | 17 | 30,000 | .75 | 15 |
| Interest on General Overhead, Insurance, and Taxes | 1,577 | .08 | 1 | 2,504 | .06 | 1 |
| Subtotal | 48,517 | 2.42 | 43 | 78,209 | 1.95 | 38 |
| Variable Cost Items | | | | | | |
| Materials | 45,095 | 2.24 | 40 | 90,185 | 2.24 | 44 |
| Machinery and Equipment | 3,675 | .18 | 3 | 6,282 | .16 | 3 |
| Labor | 10,341 | .52 | 10 | 20,676 | .51 | 10 |
| Interest on Operating Capital | 4,425 | .22 | 4 | 8,776 | .22 | 5 |
| Subtotal | 63,536 | 3.16 | 57 | 125,919 | 3.13 | 62 |
| Total Annual Costs | 112,053 | 5.58 | 100 | 204,128 | 5.08 | 100 |

*Total Nursery - 17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space.
Slow Growing Evergreens, 68,000 sq ft of growing space, 40,800 sq ft of polyhouse space, 20,085 12-15 inch salable plants per year.
**Total Nursery - 33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space.
Slow Growing Evergreens, 136,000 sq ft of growing space, 81,600 sq ft of polyhouse space, 40,165 12-15 inch salable plants per year.

cent on labor. Variable costs for materials and interest on operating capital were the same for both sized nurseries.

In the nurseries analyzed, it cost 10% less to produce a 12-15 inch salable slow-growing evergreen (*Taxus*) in the large nursery than in the small. While the overall reduction was 10%, it was 24% for fixed costs and only 1% for variable. Large-sized commercial container nurseries are able to make more efficient use of buildings, equipment, and machinery than small container nurseries.

Individual nurserymen might well experience or at least calculate costs considerably different than those depicted here. Most cost differences would probably be reflected in fixed rather than variable costs. Most fixed costs are implicit and their full impact may not be calculated by established nurserymen. Budgets presented assumed new facilities, machinery, and equipment. Most nurserymen have owned their land for many years and have used machinery and equipment. For the established nursery, budgeted fixed costs on land improvements, buildings, machinery, and equipment presented here would reflect replacement rather than 'book' value of depreciated items. Presented fixed costs also placed a market value on management. Many nurserymen place little if any value on their own management when computing costs. Variable items, on the other hand, are explicit, experienced at least yearly, and easily accounted for. Variable costs presented here would be typical for the industry in Ohio and should be rather consistent regardless of age and size of the nursery.

## SUMMARY

Total annual costs per salable slow-growing evergreen (*Taxus*) were $5.58 in the small nursery and $5.08 in the large. Fixed costs were $2.42 in the small nursery and $1.95 in the large, for a differential of 47 cents per salable plant. Variable costs, on the other hand, were $3.16 in the small and $3.13 in the large for a differential of only 3 cents. These per plant costs assumed a 2-year growing cycle, production in 2-gallon containers, and an average size of 12-15 inches per salable plant.

These figures demonstrated that variable costs on a salable plant basis, at least over the size range of nurseries analyzed, remain reasonably constant. The small nursery could purchase materials and other variable items almost as cheaply as the large. Fixed costs in contrast changed significantly as size of nursery increased. This occurred because most of the fixed factors required to operate the small nursery such as management, buildings, and most machinery and equipment were also adequate to operate the large. As the size of nursery increased, costs for fixed items of production were spread over more salable units, thereby reducing the fixed cost per plant.

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# Annual Costs of Producing Upright Deciduous Shrubs (*Viburnum*) Differentiated by Size of Firm in Ohio

HAROLD H. KNEEN, REED D. TAYLOR, DAVID E. HAHN, AND ELTON M. SMITH[1]

## ABSTRACT

The objective of this study was to determine annual production costs of upright deciduous shrubs in containers in Ohio differentiated by size of firm. This objective was accomplished by synthesizing two model container nurseries using the conceptual framework of economic engineering. Once the nurseries were synthesized, growing space was divided into five equal parts with each part being assigned a plant group. In the small container nursery, upright deciduous shrubs were allocated 68,000 sq ft of growing space and 40,800 sq ft of polyhouse space. For the large nursery, the figures were 136,000 and 81,600 sq.ft., respectively. One specific species of upright deciduous shrub, *Viburnum*, was chosen for detailed analysis. In the space allocated, 16,185 18-24 inch salable *Viburnum* could be produced annually in the small nursery and 32,380 in the large. Total annual costs per salable plant were $5.84 in the small nursery and $5.22 in the large. These costs were based on 1982 figures and assumed a 2-year growing cycle with production in 2-gallon containers.

## INTRODUCTION

Upright deciduous shrubs including various species of *Viburnum*, *Weigela*, *Forsythia*, and *Ligustrum* have always been very important in the Ohio landscape. As a group they encompass a wide range of growing habits, size, foliage, flower, and fruit colors and they can be effectively used in many ways in the landscape. Most upright deciduous shrubs being grown in Ohio are quite hardy and require only minimum overwinter protection even when being grown in containers.

The specific objective of this study was to determine annual production costs for upright deciduous shrubs in containers in Ohio differentiated by size of firm. This information should aid Ohio nurserymen in their decisions regarding which plants to grow and in what quantities.

## MATERIALS AND METHODS

In the study, two model firms were synthesized using the conceptual framework of economic engineering wherein the 'best proven practice' was included in each model. They were synthesized based on the Columbus, Ohio, area. The complete synthesis included developing an appropriate production cycle; schematic drawings of the physical layout, including buildings and irrigation system; lists of equipment and other items; a complete sequence by month and year of nursery operation steps beginning with the purchase of plant liners and ending with loading the finished product for wholesale distribution; and budgets for fixed and variable costs (3).

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during 1982. The basic goals in synthesizing the production facilities were to minimize labor expenses, flow and movement of plant material and equipment, water runoff, and initial investment, and to maximize the number of salable plants and keep future expansion possible. See Taylor *et al.* (3) for a detailed analysis of the physical plant, production system, and capital and production budgets.[2] Kneen *et al.* (1) provide a rather precise summary of capital requirements for establishing container nurseries in Ohio.

The production system chosen for this analysis consists of utilizing husky 2-year-old bareroot liners to produce a salable plant within two growing seasons. These 6-7" liners are transplanted directly into 2-gallon (8 ½" x 8") copolymer containers during the month of May. Approximately 10% of the crop will be sold during the fall of the second growing season (approximately 18 months), 65% during March and April after the second growing season (approximately 22-23 months), and 25% during May after the second growing season (24 months). May is a period when clean-up sales are being made and new plants started. This production system saves transplanting as the plants are sold in the same containers in which they are started (2 gallon).

A model facility was synthesized for both a small (340,000 sq ft of growing area) and a large (680,000 sq ft of growing area) container nursery. The nursery operations were assumed to produce a diverse line of nursery stock each having a 2-year production cycle. Commonly grown nursery stock was divided into five cultural groups. While not all-inclusive, the groups do permit a range of per unit costs to be developed as they relate to input costs and cultural factors. For analytical purposes, it was assumed that each cultural group would occupy 20% of the growing area (*i.e.*, small nursery = 68,000 sq ft per group; large nursery = 136,000 sq ft per group). Costs developed on upright deciduous shrubs (*Viburnum*) therefore were based on the scale of the complete nursery, but analyzed on the basis of percent of total space occupied. A report on spreading evergreens (*Juniperus*) using equivalent 1982 data was previously published (2), while companion studies in

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this publication report on spreading deciduous shrubs (page 39), slow-growing evergreens (page 45), and broadleaf evergreens (page 55).

For detailed analysis on upright deciduous shrubs, one specific plant type (*Viburnum*) was chosen. While it is recognized that other upright deciduous shrubs would have somewhat different requirements, it was felt that the requirements would not vary significantly in cost from the *Viburnum*. Among others, the category of upright deciduous shrubs would include various species of *Buxus*. Some of their unique cultural characteristics would be hardwood bark medium and hardiness. They would require minimum overwinter protection. Thermal blankets within the polyhouses would not be required.

Costs were established for all factors of production including management and invested capital. In economic terms, costs associated with factors of production inputted by owner/operators are often referred to as 'opportunity costs' or the income these factors could have received if they were employed elsewhere. For example, owners could usually be employed as manag-

TABLE 1.--Annual Variable Costs (Dollars) for Upright Deciduous Shrubs (Viburnum) for a Small* Container Nursery in Ohio, 1982.

| Item | Description | Unit | Cost per Unit | Quantity | Total Variable Cost |
|---|---|---|---|---|---|
| Materials | | | | | |
| Container | #2, 8 1/2" x 8" copolymer propylene | each | 0.29 | 17,040.00 | 4,942 |
| Soil mixture | Hardwood bark, sand, nutrients | cu yd | 31.00 | 136.32 | 4,226 |
| Liners | 2-year 6-7" liner | each | 1.00 | 17,040.00 | 17,040 |
| Polyethylene film | 4 mil white, 32' x 225' | each | 107.00 | 10.20 | 1,091 |
| Strip tags | 5/8" x 7" plastic strip tag | each | .02 | 16,185.00 | 324 |
| Chemicals | Oxadiazon 4G (Ronstar) (herbicide) | pound | .90 | 292.00 | 263 |
| | Benomyl 50 WP (Benlate) (fungicide) | pound | 10.00 | 6.00 | 60 |
| | Demetron 6 (Metra-Systox-M) (insecticide) | ounces | .71 | 52.00 | 37 |
| | Cyhexatin 50WP (Kelthane) (miticide) | pound | 22.25 | 1.50 | 33 |
| | Chlorothalonil 10M cu ft (Termil) (fungicide) | canister | 1.90 | 60.20 | 114 |
| | Osmocote 8-9 mo (18-6-12) | pound | .86 | 2,674.42 | 2,300 |
| | Urea 45-0-0 (fertilizer) | pound | .13 | 2,628.40 | 342 |
| | Glyphosate (Roundup) (herbicide) | quart | 16.60 | 2.80 | 46 |
| Subtotal | | | | | 30,818 |
| Machinery and Equipment | | | | | |
| | Tractor, 60 HP | hour | 15.85 | 26.60 | 422 |
| | Tractor, 28 HP | hour | 4.92 | 103.40 | 509 |
| | Manure spreader, 130 bu | hour | 1.58 | 8.60 | 14 |
| | Wagon, 4-wheel | hour | 0.53 | 155.60 | 82 |
| | Irrigation/well, pump 75 HP | hour | 6.65 | 147.00 | 978 |
| | Inground irrigation system | hour | 1.54 | 147.00 | 226 |
| | Above ground irrigation system | hour | 3.09 | 147.00 | 454 |
| | Fertilizer injector | hour | 4.33 | 24.00 | 104 |
| | Airblast sprayer | hour | 23.98 | 3.20 | 77 |
| | Forklift | hour | 6.59 | 26.00 | 171 |
| | 1/2 ton pick-up truck | hour | 8.51 | 75.00 | 638 |
| Subtotal | | | | | 3,675 |
| Labor | | | | | |
| | Labor hours | hour | 5.15** | 1,348.00 | 6,942 |
| | Related labor hours | hour | 5.15 | 270.00 | 1,391 |
| Subtotal | | | | | 8,333 |
| Interest Charge on Operating Capital | Computed at 15% on an annual basis for 6 months | percent | 7.5 (0.075) | 42,762.00 | 3,207 |
| Total Annual Variable Costs | | | | | 46,033 |
| Annual Variable Cost per 18-24 Inch Salable Plant | | | | | 2.84 |

*Total Nursery - 17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space.
Upright Deciduous Shrubs, 68,000 sq ft of growing space, 40,800 sq ft of polyhouse space, 16,185 18-24 inch salable plants per year.

**Average basic wage before withholding taxes and fringes $4.30, taxes and fringes add 19.84% or $0.85 for a total of $5.15.

ers at other nurseries, and money invested in land, buildings, irrigation systems, and equipment could have earned interest if it had been placed in financial institutions.

Capital requirements for establishing the nurseries were first determined (1). Second, capital requirements per salable plant capacity by spacing and size of nursery were established (3). Third, annual fixed costs were calculated (see page 31). Fourth, annual variable costs were determined for each of the two sized nurseries (Tables 1 and 2). Fifth, summaries were made for annual fixed and variable costs for each of the plant groups according to size of nursery (Table 3). This allowed cost comparisons based on size of nursery.

Most nurseries use cash rather than accrual accounting procedures. For this reason, the analyses were completed on a "cash" basis. Analysis on a cash basis does not give a true economic picture of the cost of producing a plant as it does not take into account the time value of money from the time the plant is planted until it is harvested. The analyses do, however, give a true estimate of the annual cost per salable plant.

TABLE 2.--Annual Variable Costs (Dollars) for Upright Deciduous Shrubs (Viburnum) for a Large* Container Nursery in Ohio, 1982.

| Item | Description | Unit | Cost per Unit | Quantity | Total Variable Cost |
|---|---|---|---|---|---|
| Materials | | | | | |
| Container | #2, 8 1/2" x 8" copolymer propylene | each | 0.29 | 34,085.00 | 9,885 |
| Soil mixture | Hardwood bark, sand, nutrients | cu yd | 31.00 | 272.68 | 8,453 |
| Liners | 2-year 6-7" liner | each | 1.00 | 34,085.00 | 34,085 |
| Polyethylene film | 4 mil white, 32' x 225' | each | 107.00 | 20.40 | 2,183 |
| Strip tags | 5/8" x 7" plastic strip tag | each | .02 | 32,380.00 | 648 |
| Chemicals | Oxadiazon 4G (Ronstar) (herbicide) | pound | .90 | 597.00 | 537 |
| | Benomyl 50 WP (Benlate) (fungicide) | pound | 10.00 | 12.40 | 124 |
| | Demetron 6 (Meta-Systox-M) (insecticide) | ounces | .71 | 106.00 | 75 |
| | Cyhexatin 50WP (Kelthane) (miticide) | pound | 22.25 | 3.20 | 71 |
| | Chlorothalonil 10M cu ft (Termil) (fungicide) | canister | 1.90 | 122.00 | 232 |
| | Osmocote 8-9 mo (18-6-12) | pound | .86 | 5,351.16 | 4,602 |
| | Urea 45-0-0 (fertilizer) | pound | .13 | 5,043.40 | 656 |
| | Glyphosate (Roundup) (herbicide) | quart | 16.60 | 5.60 | 93 |
| Subtotal | | | | | 61,644 |
| Machinery and Equipment | | | | | |
| | Tractor, 60 HP | hour | 15.85 | 54.00 | 856 |
| | Tractor, 28 HP | hour | 4.92 | 210.00 | 1,033 |
| | Manure spreader, 130 bu | hour | 1.58 | 17.40 | 27 |
| | Wagon, 4-wheel | hour | 0.53 | 316.00 | 167 |
| | Irrigation/well, pump 75 HP | hour | 6.65 | 200.40 | 1,333 |
| | Inground irrigation system | hour | 1.54 | 200.40 | 309 |
| | Above ground irrigation system | hour | 3.09 | 200.40 | 619 |
| | Fertilizer injector | hour | 4.33 | 36.00 | 156 |
| | Airblast sprayer | hour | 23.98 | 6.60 | 158 |
| | Forklift | hour | 6.59 | 52.80 | 348 |
| | 1/2 ton pick-up truck | hour | 8.51 | 150.00 | 1,276 |
| Subtotal | | | | | 6,282 |
| Labor | | | | | |
| | Labor hours | hour | 5.15** | 2,695.00 | 13,879 |
| | Related labor hours | hour | 5.15 | 539.00 | 2,776 |
| Subtotal | | | | | 16,655 |
| Interest Charge on Operating Capital | Computed at 15% on an annual basis for 6 months | percent | 7.5 (0.075) | 84,447.00 | 6,334 |
| Total Annual Variable Costs | | | | | 90,915 |
| Annual Variable Cost per 18-24 Inch Salable Plant | | | | | 2.81 |

*Total Nursery - 33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space. Upright Deciduous Shrubs, 136,000 sq ft of growing space, 81,600 sq ft of polyhouse space, 32,380 18-24 inch salable plants per year.

**Average basic wage before withholding taxes and fringes $4.30, taxes and fringes add 19.84% or $0.85 for a total of $5.15.

Total annual production costs consist of both fixed and variable factors. Fixed costs are primarily made up of implicit costs such as depreciation on buildings and equipment, interest charges (both for borrowed and equity capital), and charges for management. Many nurserymen do not adequately consider fixed costs when computing costs of production. Fixed items are often considered as residual claimants on income. For example, management is compensated if all other factors of production have been accounted for. As noted previously, annual fixed costs are discussed in greater detail in a companion article.

Variable costs include all cost factors that vary with the quantity of plants being grown at one point in time. Variable costs are explicit, obvious, and normally paid out yearly. Variable costs were subdivided into the following categories: materials, machinery and equipment, labor, and interest on operating capital (Tables 1 and 2). Details on specific variable cost items are included in the companion article on spreading deciduous shrubs (page 39).

After all cost factors were determined, they were summarized based upon cost per salable plant by size of nursery.

## RESULTS AND DISCUSSION

Annual fixed, variable, and total production costs of producing upright deciduous shrubs (*Viburnum*) in container nurseries in Ohio for 1982 are summarized in Table 3. In the small nursery, total annual costs were $94,550 or $5.84 per salable 18-24 inch plant. Fixed costs totaled $48,517 or $3.00 per plant and made up 51% of total costs. Based on percentage of total costs, land and improvements made up 9%, buildings 11%, machinery and equipment 9%, general overhead 20%, and interest on general overhead, insurance, and taxes 2%. Variable costs totaled $46,033 or $2.84 per plant and made up 49% of total costs. Based on percentage of total costs, materials made up 33%, machinery and equipment 4%, labor 9%, and interest on operating capital 3%.

In the large nursery, total annual costs were $169,124 or $5.22 per salable 18-24 inch plant. Fixed costs totaled $78,209 or $2.42 per plant and made up 46% of total costs. Based on percentage of total costs, land and improvements made up 10%, buildings 9%, machinery and equipment 8%, general overhead 18%, and interest on general overhead, insurance, and taxes 1%. Variable costs totaled $90,915 or $2.80 per plant and made up 54% of total costs. Based on percentage of total costs, materials made up 36%, machinery and equipment 4%, labor 10%, and interest on operating capital 4%.

Total annual costs were 62 cents per plant more in the small nursery than in the large. Of this 62 cents, 58 cents or 94% were made up of fixed costs. On a per item basis, the large nursery's advantages were 2 cents on land and improvements, 13 cents on buildings, 15 cents on machinery and equipment, 26 cents on general overhead, and 2 cents on interest for general overhead, insurance, and taxes. The 4 cents for variable costs were all accounted for by machinery and equipment. Variable

Table 3.--Summary of Annual Fixed, Variable, and Total Costs (Dollars) of Producing Upright Deciduous Shrubs (Viburnum) in Containers in Ohio, 1982.

| | Small Container Nursery* | | | Large Container Nursery** | | |
|---|---|---|---|---|---|---|
| Item | Cost | Cost per Salable Plant | Percent of Total Cost | Cost | Cost per Salable Plant | Percent of Total Cost |
| Fixed Cost Items | | | | | | |
| Land and Improvements | 8,616 | .53 | 9 | 16,436 | .51 | 10 |
| Buildings | 10,190 | .63 | 11 | 16,127 | .50 | 9 |
| Machinery and Equipment | 9,129 | .56 | 9 | 13,142 | .41 | 8 |
| General Overhead | 19,005 | 1.18 | 20 | 30,000 | .92 | 18 |
| Interest on General Overhead, Insurance, and Taxes | 1,577 | .10 | 2 | 2,504 | .08 | 1 |
| Subtotal | 48,517 | 3.00 | 51 | 78,209 | 2.42 | 46 |
| Variable Cost Items | | | | | | |
| Materials | 30,818 | 1.90 | 33 | 61,644 | 1.90 | 36 |
| Machinery and Equipment | 3,675 | .23 | 4 | 6,282 | .19 | 4 |
| Labor | 8,333 | .51 | 9 | 16,655 | .51 | 10 |
| Interest on Operating Capital | 3,207 | .20 | 3 | 6,334 | .20 | 4 |
| Subtotal | 46,033 | 2.84 | 49 | 90,915 | 2.80 | 54 |
| Total Annual Costs | 94,550 | 5.84 | 100 | 169,124 | 5.22 | 100 |

*Total Nursery - 17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space.
Upright Deciduous Shrubs, 68,000 sq ft of growing space, 40,800 sq ft of polyhouse space, 16,185 18-24 inch salable plants per year.

**Total Nursery - 33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space.
Upright Deciduous Shrubs, 136,000 sq ft of growing space, 81,600 sq ft of polyhouse space, 32,380 18-24 inch salable plants per year.

costs for materials, labor, and interest on operating capital were the same for both sized nurseries.

In the nurseries analyzed, it cost 12% less to produce an 18-24 inch salable upright deciduous shrub (*Viburnum*) in the large nursery than in the small. While the overall reduction was 12%, it was 24% for fixed costs and only 1% for variable. Large-sized commercial container nurseries are able to make more efficient use of buildings, equipment, and machinery than small container nurseries.

Individual nurserymen might well experience or at least calculate costs considerably different than those depicted here. Most cost differences would probably be reflected in fixed rather than variable costs. Most fixed costs are implicit and their full impact may not be calculated by established nurserymen. Budgets presented assumed new facilities, machinery, and equipment. Most nurserymen have owned their land for many years and have used machinery and equipment. For the established nursery, budgeted fixed costs on land improvements, buildings, machinery, and equipment presented here would reflect replacement rather than 'book' value of depreciated items. Presented fixed costs also placed a market value on management. Many nurserymen place little if any value on their own management when computing costs. Variable items, on the other hand, are explicit, experienced at least yearly, and easily accounted for. Variable costs presented here would be typical for the industry in Ohio and should be rather consistent regardless of age and size of the nursery.

## SUMMARY

Total annual costs per salable upright deciduous shrub (*Viburnum*) were $5.84 in the small nursery and $5.22 in the large. Fixed costs were $3.00 in the small nursery and $2.42 in the large, for a differential of 48 cents per salable plant. Variable costs, on the other hand, were $2.84 in the small and $2.80 in the large for a differential of only 4 cents. These per plant costs assumed a 2-year growing cycle, production in 2-gallon containers, and an average size of 18-24 inches per salable plant.

These figures demonstrated that variable costs on a salable plant basis, at least over the size range of nurseries analyzed, remain reasonably constant. The small nursery could purchase materials and other variable items almost as cheaply as the large. Fixed costs in contrast changed significantly as size of nursery increased. This occurred because most of the fixed factors required to operate the small nursery such as management, buildings, and most machinery and equipment were also adequate to operate the large. As the size of nursery increased, costs for fixed items of production were spread over more salable units, thereby reducing the fixed cost per plant.

## LITERATURE CITED

1. Kneen, Harold H., Reed D. Taylor, David E. Hahn, and Elton M. Smith. 1983. Capital requirements for establishing container nurseries in Ohio—1982. Ohio Agri. Res. and Dev. Ctr., Res. Circ. 274, Ornamental Plants—1983: A Summary of Research, pp. 3-8.
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# Annual Costs of Producing Broadleaf Evergreens (*Rhododendron*) Differentiated by Size of Firm in Ohio

HAROLD H. KNEEN, REED D. TAYLOR, DAVID E. HAHN, AND ELTON M. SMITH[1]

## ABSTRACT

The objective of this study was to determine annual production costs of broadleaf evergreens in containers in Ohio differentiated by size of firm. This objective was accomplished by synthesizing two model container nurseries using the conceptual framework of economic engineering. Once the nurseries were synthesized, growing space was divided into five equal parts with each part being assigned a plant group. In the small container nursery, slow-growing evergreens were allocated 68,000 sq ft of growing space and 40,800 sq ft of polyhouse space. For the large nursery, the figures were 136,000 and 81,600 sq ft, respectively. One specific species of broadleaf evergreen (*Rhododendron*) was chosen for detailed analysis. In the space allocated, 13,050 15-18 inch salable *Rhododendron* could be produced annually in the small nursery and 26,095 in the large. Total annual costs per salable plant were $7.36 in the small nursery and $6.59 in the large. These costs were based on 1982 figures and assumed a 2-year growing cycle with production in 2-gallon containers.

## INTRODUCTION

Broadleaf evergreens, produced for their uniquely textured foliage and beautiful flowers, require considerable care to produce in containers. They typically require more space than other species of the same size and also need considerable overwintering protection. These requirements make them considerably more expensive to produce than most other container plants.

The specific objective of this study was to determine annual production costs for broadleaf evergreens in containers in Ohio differentiated by size of firm. This information should aid Ohio nurserymen in their decisions regarding which plants to grow and in what quantities.

## MATERIALS AND METHODS

In the study, two model firms were synthesized using the conceptual framework of economic engineering wherein the 'best proven practice' was included in each model. They were synthesized based on the Columbus, Ohio, area. The complete synthesis included developing an appropriate production cycle; schematic drawings of the physical layout, including buildings and irrigation systems; lists of equipment and other items; a complete sequence by month and year of nursery operational steps beginning with the purchase of plant liners and ending with loading the finished product for wholesale distribution; and budgets for fixed and variable costs (3).

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during 1982. The basic goals in synthesizing the production facilities were to minimize labor expenses, flow and movement of plant material and equipment, water runoff, and initial investment, and to maximize the number of salable plants and keep future expansion possible. See Taylor *et al.* (3) for a detailed analysis of the physical plant, production system, and capital and production budgets.[2] Kneen *et al.* (1) provide a rather precise summary of capital requirements for establishing container nurseries in Ohio.

The production system chosen for this analysis consists of utilizing husky 2-year-old bareroot liners to produce a salable plant within two growing seasons. These 6-7" liners are transplanted directly into 2-gallon (8½" x 8") copolymer containers during the month of May. Approximately 10% of the crop will be sold during the fall of the second growing season (approximately 18 months), 65% during March and April after the second growing season (approximately 22-23 months), and 25% during May after the second growing season (24 months). May is a period when clean-up sales are being made and new plants started. This production system saves transplanting as the plants are sold in the same containers in which they are started (2 gallon).

A model facility was synthesized for both a small (340,000 sq ft of growing area) and a large (680,000 sq ft of growing area) container nursery. The nursery operations were assumed to produce a diverse line of nursery stock each having a 2-year production cycle. Commonly grown nursery stock was divided into five cultural groups. While not all inclusive, the groups do permit a range of per unit costs to be developed as they relate to input costs and cultural factors. For analytical purposes, it was assumed that each cultural group would occupy 20% of the growing area (*i.e.*, small nursery = 68,000 sq ft per group; large nursery = 136,000 sq ft per group). Costs developed on broadleaf evergreens (*Rhododendron*) therefore were based on the scale of the complete nursery, but analyzed on the basis of percent of total space occupied. A report on spreading evergreens (*Juniperus*) using equivalent 1982 data was previously published (2), while companion studies in this publication report on spreading deciduous shrubs (page 39), slow-growing evergreens (page 45), and upright deciduous shrubs (page 50).

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[2]A copy of this publication can be obtained by writing: Dr. Reed Taylor, The Ohio State University, 2120 Fyffe Road, Columbus, Ohio 43210.

For detailed analysis on broadleaf evergreens, one specific plant type (*Rhododendron*) was chosen. While it is recognized that other broadleaf evergreens would have somewhat different requirements, it was felt that the requirements would not vary significantly in cost from the *Rhododendron*. Among others, the category of broadleaf evergreens would include various species of *Pieris* and *Pyracantha*. Some of their unique cultural characteristics would be pine bark medium and need for maximum overwinter protection.

Costs were established for all factors of production including management and invested capital. In economic terms, costs associated with factors of production inputted by owner/operators are often referred to as 'opportunity costs' or the income these factors could have received if they were employed elsewhere. For example, owners could usually be employed as managers at other nurseries, and money invested in land,

TABLE 1.--Annual Variable Costs (Dollars) for Broadleaf Evergreens (Rhododendron) for a Small* Container Nursery in Ohio, 1982.

| Item | Description | Unit | Cost per Unit | Quantity | Total Variable Cost |
|---|---|---|---|---|---|
| Materials | | | | | |
| Container | #2, 8 1/2" x 8" copolymer propylene | each | 0.29 | 13,735.00 | 3,983 |
| Soil mixture | Pine bark, sand, nutrients | cu yd | 33.00 | 110.00 | 3,630 |
| Liners | 2-year 6-7" liner | each | 1.25 | 13,735.00 | 17,169 |
| Polyethylene film | 4 mil white, 32' x 225' | each | 107.00 | 10.20 | 1,091 |
| Thermal blanket | 4 - 1/4" 80" x 225' per house | each | 775.00 | 1/3 (10.20)** | 2,635 |
| Strip tags | 5/8" x 7" plastic strip tag | each | .02 | 13,050.00 | 261 |
| Chemicals | Oxadiazon 4G (Ronstar) (herbicide) | pound | .90 | 292.00 | 263 |
| | Benomyl 50 WP (Benlate) (fungicide) | pound | 10.00 | 6.00 | 60 |
| | Demetron 6 (Meta-Systox-M) (insecticide) | ounces | .71 | 52.00 | 37 |
| | Cyhexatin 50WP (Kelthane) (miticide) | pound | 22.25 | 1.50 | 33 |
| | Chlorothalonil 10M cu ft (Termil) (fungicide) | canister | 1.90 | 60.20 | 114 |
| | Lesco 3-4 mo (20-6-12) | pound | .80 | 4,311.62 | 3,449 |
| | Urea 45-0-0 (fertilizer) | pound | .13 | 2,628.40 | 342 |
| | Glyphosate (herbicide) | quart | 16.60 | 2.80 | 46 |
| Subtotal | | | | | 33,113 |
| Machinery and Equipment | | | | | |
| | Tractor, 60 HP | hour | 15.85 | 26.60 | 422 |
| | Tractor, 28 HP | hour | 4.92 | 103.40 | 509 |
| | Manure spreader, 130 bu | hour | 1.58 | 8.60 | 14 |
| | Wagon, 4-wheel | hour | 0.53 | 155.60 | 82 |
| | Irrigation/well, pump 75 HP | hour | 6.65 | 147.00 | 978 |
| | Inground irrigation system | hour | 1.54 | 147.00 | 226 |
| | Above ground irrigation system | hour | 3.09 | 147.00 | 454 |
| | Fertilizer injector | hour | 4.33 | 24.00 | 104 |
| | Airblast sprayer | hour | 23.98 | 3.20 | 77 |
| | Forklift | hour | 6.59 | 26.00 | 171 |
| | 1/2 ton pick-up truck | hour | 8.51 | 75.00 | 638 |
| Subtotal | | | | | 3,675 |
| Labor | | | | | |
| | Labor hours | hour | 5.15*** | 1,176.00 | 6,056 |
| | Related labor hours | hour | 5.15 | 235.00 | 1,210 |
| Subtotal | | | | | 7,266 |
| Interest Charge on Operating Capital | Computed at 15% on an annual basis for 6 months | percent | 7.5 (0.075) | 45,956.00 | 3,447 |
| Total Annual Variable Costs | | | | | 47,501 |
| Annual Variable Cost per 15-18 Inch Salable Plant | | | | | 3.64 |

*Total Nursery - 17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space.
Broadleaf Evergreens, 68,000 sq ft of growing space, 40,800 sq ft of polyhouse space, 13,050 15-18 inch salable plants per year.

**Thermal blankets would be used for three seasons.

***Average basic wage before withholding taxes and fringes $4.30, taxes and fringes add 19.84% or $0.85 for a total of $5.15.

buildings, irrigation systems, and equipment could have earned interest if it had been placed in financial institutions.

Capital requirements for establishing the nurseries were first determined (1). Second, capital requirements per salable plant capacity by spacing and size of nursery were established (3). Third, annual fixed costs were calculated (see companion study on page 31). Fourth, annual variable costs were determined for each of the two sized nurseries (Tables 1 and 2). Fifth, summaries were made for annual fixed and variable costs for each of the plant groups according to size of nursery (Table 3). This allowed cost comparisons based on size of nursery.

Most nurseries use cash rather than accrual accounting procedures. For this reason, the analyses were completed on a "cash" basis. Analysis on a cash basis does not give a true economic picture of the cost of produc-

TABLE 2.--Annual Variable Costs (Dollars) for Broadleaf Evergreens (Rhododendron) for a Large* Container Nursery in Ohio, 1982.

| Item | Description | Unit | Cost per Unit | Quantity | Total Variable Cost |
|---|---|---|---|---|---|
| Materials | | | | | |
| Container | #2, 8 1/2" x 8" copolymer propylene | each | 0.29 | 27,470.00 | 7,966 |
| Soil mixture | Pine bark, sand, nutrients | cu yd | 33.00 | 220.08 | 7,260 |
| Liners | 2-year 6-7" liner | each | 1.25 | 27,470.00 | 34,338 |
| Polyethylene film | 4 mil white, 32' x 225' | each | 107.00 | 20.40 | 2,183 |
| Thermal blanket | 4 - 1/4' 80" x 225' per house | each | 775.00 | 1/3 (20.40)** | 5,270 |
| Strip tags | 5/8" x 7" plastic strip tag | each | .02 | 26,095.00 | 522 |
| Chemicals | Oxadiazon 4G (Ronstar) (herbicide) | pound | .90 | 597.00 | 537 |
| | Benomyl 50 WP (Benlate) (fungicide) | pound | 10.00 | 12.40 | 124 |
| | Demetron 6 (Meta-Systox-M) (insecticide) | ounces | .71 | 106.00 | 75 |
| | Cyhexatin 50WP (Kelthane) (miticide) | pound | 22.25 | 3.20 | 71 |
| | Chlorothalonil 10M cu ft (Termil) (fungicide) | canister | 1.90 | 122.00 | 232 |
| | Lesco 3-4 mo (20-6-12) | pound | .80 | 8,623.20 | 6,899 |
| | Urea 45-0-0 (fertilizer) | pound | .13 | 5,043.40 | 656 |
| | Glyphosate (Roundup) (herbicide) | quart | 16.60 | 5.90 | 93 |
| Subtotal | | | | | 66,226 |
| Machinery and Equipment | | | | | |
| | Tractor, 60 HP | hour | 15.85 | 54.00 | 856 |
| | Tractor, 28 HP | hour | 4.92 | 210.00 | 1,033 |
| | Manure spreader, 130 bu | hour | 1.58 | 17.40 | 27 |
| | Wagon, 4-wheel | hour | 0.53 | 316.00 | 167 |
| | Irrigation/well, pump 75 HP | hour | 6.65 | 200.40 | 1,333 |
| | Inground irrigation system | hour | 1.54 | 200.40 | 309 |
| | Above ground irrigation system | hour | 3.09 | 200.40 | 619 |
| | Fertilizer injector | hour | 4.33 | 36.00 | 156 |
| | Airblast sprayer | hour | 23.98 | 6.60 | 158 |
| | Forklift | hour | 6.59 | 52.80 | 348 |
| | 1/2 ton pick-up truck | hour | 8.51 | 150.00 | 1,276 |
| Subtotal | | | | | 6,282 |
| Labor | | | | | |
| | Labor hours | hour | 5.15*** | 2,350.00 | 12,103 |
| | Related labor hours | hour | 5.15 | 470.00 | 2,421 |
| Subtotal | | | | | 14,524 |
| Interest Charge on Operating Capital | Computed at 15% on an annual basis for 6 months | percent | 7.5 (0.075) | 90,828.00 | 6,812 |
| Total Annual Variable Costs | | | | | 93,844 |
| Annual Variable Cost per 15-18 Inch Salable Plant | | | | | 3.60 |

*Total Nursery - 33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space.
Broadleaf Evergreens, 136,000 sq ft of growing space, 81,600 sq ft of polyhouse space, 26,095 15-18 inch salable plants per year.

**Thermal blankets would be used for three seasons.

***Average basic wage before withholding taxes and fringes $4.30, taxes and fringes add 19.84% or $0.85 for a total of $5.15.

ing a plant as it does not take into account the time value of money from the time the plant is planted until it is harvested. The analyses do, however, give a true estimate of the annual cost per salable plant.

Total annual production costs consist of both fixed and variable factors. Fixed costs are primarily made up of implicit costs such as depreciation on buildings and equipment, interest charges (both for borrowed and equity capital), and charges for management. Many nurserymen do not adequately consider fixed costs when computing costs of production. Fixed items are often considered as residual claimants on income. For example, management is compensated if all other factors of production have been accounted for. As noted previously, annual fixed costs are discussed in greater detail in a companion article.

Variable costs include all cost factors that vary with the quantity of plants being grown at one point in time. Variable costs are explicit, obvious, and normally paid out yearly. Variable costs were subdivided into the following categories: materials, machinery and equipment, labor, and interest on operating capital (Tables 1 and 2). Details on specific variable cost items are included in the companion article on spreading deciduous shrubs (page 39).

After all cost factors were determined, they were summarized based upon cost per salable plant by size of nursery.

## RESULTS AND DISCUSSION

Annual fixed, variable, and total production costs of producing broadleaf evergreens (*Rhododendron*) in container nurseries in Ohio for 1982 are summarized in Table 3. In the small nursery, total annual costs were $96,018 or $7.36 per salable 15-18 inch plant. Fixed costs totaled $48,517 or $3.72 per plant and made up 51% of total costs. Based on percentage of total costs, land and improvements made up 9%, buildings 11%, machinery and equipment 9%, general overhead 20%, and interest on general overhead, insurance, and taxes 2%. Variable costs totaled $47,501 or $3.64 per plant and made up 49% of total costs. Based on percentage of total costs, materials made up 35%, machinery and equipment 4%, labor 7%, and interest on operating capital 3%.

In the large nursery, total annual costs were $172,053 or $6.59 per salable 15-18 inch plant. Fixed costs totaled $78,209 or $3.00 per plant and made up 46% of total costs. Based on percentage of total costs, land and improvements made up 10%, buildings 9%, machinery and equipment 8%, general overhead 17%, and interest on general overhead, insurance, and taxes 2%. Variable costs totaled $93,844 or $3.60 per plant and made up 54% of total costs. Based on percentage of total costs, materials made up 39%, machinery and equipment 3%, labor 8%, and interest on operating capital 4%.

Total annual costs were 77 cents per plant more in the small nursery than in the large. Of this 77 cents, 72 cents

Table 3.--Summary of Annual Fixed, Variable, and Total Costs (Dollars) of Producing Broadleaf Evergreens (Rhododendron) in Containers in Ohio, 1982.

| Item | Small Container Nursery* | | | Large Container Nursery** | | |
|---|---|---|---|---|---|---|
| | Cost | Cost per Salable Plant | Percent of Total Cost | Cost | Cost per Salable Plant | Percent of Total Cost |
| Fixed Cost Items | | | | | | |
| Land and Improvements | 8,616 | .66 | 9 | 16,436 | .63 | 10 |
| Buildings | 10,190 | .78 | 11 | 16,127 | .62 | 9 |
| Machinery and Equipment | 9,129 | .70 | 9 | 13,142 | .50 | 8 |
| General Overhead | 19,005 | 1.46 | 20 | 30,000 | 1.15 | 17 |
| Interest on General Overhead, Insurance, and Taxes | 1,577 | .12 | 2 | 2,504 | .10 | 2 |
| Subtotal | 48,517 | 3.72 | 51 | 78,209 | 3.00 | 46 |
| Variable Cost Items | | | | | | |
| Materials | 33,113 | 2.54 | 35 | 66,226 | 2.54 | 39 |
| Machinery and Equipment | 3,675 | .28 | 4 | 6,282 | .24 | 3 |
| Labor | 7,266 | .56 | 7 | 14,524 | .56 | 8 |
| Interest on Operating Capital | 3,447 | .26 | 3 | 6,812 | .26 | 4 |
| Subtotal | 47,501 | 3.64 | 49 | 93,844 | 3.60 | 54 |
| Total Annual Costs | 96,018 | 7.36 | 100 | 172,053 | 6.59 | 100 |

*Total Nursery - 17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space.
Broadleaf Evergreens, 68,000 sq ft of growing space, 40,800 sq ft of polyhouse space, 13,050 15-18 inch salable plants per year.
**Total Nursery - 33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space.
Broadleaf Evergreens, 136,000 sq ft of growing space, 81,600 sq ft of polyhouse space, 26,095 15-18 inch salable plants per year.

or 94% were made up of fixed costs. On a per item basis, the large nursery's advantages were 3 cents on land and improvements, 16 cents on buildings, 20 cents on machinery and equipment, 31 cents on general overhead, and 2 cents on interest for general overhead, insurance, and taxes. The 5 cents for variable costs was all accounted for by machinery and equipment. Variable costs for materials, labor, and interest on operating capital were the same for both sized nurseries.

In the nurseries analyzed, it cost 12% less to produce a 15-18 inch salable broadleaf evergreen (*Rhododendron*) in the large nursery than in the small. While the overall reduction was 12%, it was 24% for fixed costs and only 1% for variable. Large-sized commercial container nurseries are able to make more efficient use of buildings, equipment, and machinery than small container nurseries.

Individual nurserymen might well experience or at least calculate costs considerably different than those depicted here. Most cost differences would probably be reflected in fixed rather than variable costs. Most fixed costs are implicit and their full impact may not be calculated by established nurserymen. Budgets presented assumed new facilities, machinery, and equipment. Most nurserymen have owned their land for many years and have used machinery and equipment. For the established nursery, budgeted fixed costs on land improvements, buildings, machinery, and equipment presented here would reflect replacement rather than 'book' value of depreciated items. Presented fixed costs also placed a market value on management. Many nurserymen place little if any value on their own management when computing costs. Variable items, on the other hand, are explicit, experienced at least yearly, and easily accounted for. Variable costs presented here would by typical for the industry in Ohio and should be rather consistent regardless of age and size of the nursery.

## SUMMARY

Total annual costs per salable broadleaf evergreen (*Rhododendron*) were $7.36 in the small nursery and $6.59 in the large. Fixed costs were $3.72 in the small nursery and $3.00 in the large for a differential of 72 cents per salable plant. Variable costs, on the other hand, were $3.64 in the small and $3.60 in the large, for a differential of only 4 cents. These per plant costs assumed a 2-year growing cycle, production in 2-gallon containers, and an average size of 15-18 inches per salable plant.

These figures demonstrated that variable costs on a salable plant basis, at least over the size range of nurseries analyzed, remain reasonably constant. The small nursery could purchase materials and other variable items almost as cheaply as the large. Fixed costs in contrast changed significantly as size of nursery increased. This occurred because most of the fixed factors required to operate the small nursery such as management, buildings, and most machinery and equipment were also adequate to operate the large. As the size of nursery increased, costs for fixed items of production were spread over more salable units, thereby reducing the fixed cost per plant.

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# Comparative Costs of Producing Container Grown Plants in Ohio Differentiated by Size of Firm and Species of Plant

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## ABSTRACT

The objective of this study was to compare the costs of producing container grown plants in Ohio differentiated by size of firm and species of plant. Total annual costs per salable plant in the small nursery by species were $4.50 for spreading evergreens (*Juniperus*), $5.04 for spreading deciduous shrubs (*Cotoneaster*), $5.58 for slow-growing evergreens (*Taxus*), $5.84 for upright deciduous shrubs (*Viburnum*), and $7.36 for broadleaf evergreens (*Rhododendron*), averaging $5.46 across all species. For the large nursery, the comparable figures were $4.07 for spreading evergreens (*Juniperus*), $4.56 for spreading deciduous shrubs (*Cotoneaster*), $5.08 for slow-growing evergreens (*Taxus*), $5.22 for upright deciduous shrubs (*Viburnum*), and $6.59 for broadleaf evergreens (*Rhododendron*), averaging $4.92 across all groups. Fixed costs accounted for more than 90% and variable costs less than 10% of the cost differentials between the two sized nurseries. Cost differences between species were caused primarily by space requirements, cost of liners, and overwintering needs.

## INTRODUCTION

Nurserymen throughout the United States have been gradually shifting from field to container production for many species of plants. Containers allow greater flexibility in production and marketing and in most cases are less expensive than field production (1). Consequently, this has encouraged large companies to enter production and marketing. The result has been escalating competition and narrowing profit margins. Most nurserymen also lack the necessary expertise to systematically determine production costs. Due to increasing competition and periodically a slack economy, many operators find themselves in a precarious financial position. Survival under these conditions requires excellent production and marketing procedures.

The purpose of this research was to provide nursery operators with production and financial information for decision making. This information should prove especially useful to individuals anticipating beginning a container nursery and to present field operators anticipating expanding to containers. It should also prove useful to present nurserymen with container operations who anticipate updating and expansion. Another value would be in identifying segments within present operations that might be bottlenecks which result in cost inefficiencies.

## MATERIALS AND METHODS

In the study, two model firms were synthesized using the conceptual framework of economic engineering wherein the 'best proven practice' was included in each model (4). They were synthesized based on the Columbus, Ohio, area. Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during 1982.

The production system chosen consists of utilizing husky 2 or 3-year-old bareroot liners to produce a salable plant within two growing seasons. These 6-7" liners are transplanted directly into 2-gallon (8 ½" x 8") copolymer containers during the month of May. Approximately 10% of the crop will be sold during the fall of the second growing season (approximately 18 months), 65% during March and April after the second growing season (approximately 22-23 months), and 25% during May after the second growing season (24 months). May ia a period when clean-up sales are being made and new plants started. This production system saves transplanting as the plants are sold in the same containers in which they are started (2 gallon).

The nursery operations were assumed to produce a diverse line of nursery stock each having a 2-year production cycle. Commonly grown nursery stock was divided into five cultural groups. While not all inclusive, the groups do permit a range of per unit costs to be developed as they relate to input costs and cultural factors. For analytical purposes, it was assumed that each cultural group would occupy 20% of the growing area (*i.e.*, small nursery = 68,000 sq ft per group; large nursery = 136,000 sq ft per group). The small container operation would be comprised of 198,745 units in full production and the large operation 399,160 units. Annual sales capacity for the small operation would be 95,650 units and for the large operation 192,095 units. For detailed analysis, one specific plant from each group was chosen as representative of the group. While it is recognized that other plants from each category would have somewhat different requirements, it was felt that the requirements would not vary significantly in cost from the plant chosen as representative. The five groups, with some of their cultural characteristics, are discussed in a companion article (page 31).

Costs were established for all factors of production including management and invested capital. Since most nurseries use cash rather than accrual procedures, the analyses were completed on a "cash" basis.

Capital requirements for establishing the nurseries were first determined and were reported in a previous publication (2). Second, annual fixed costs were calculated and are reported in a companion article (page 31). Third, annual variable costs were calculated and added

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to fixed costs to determine annual total costs for the representative plant species for each sized nursery. An analysis of annual costs producing *Juniperus chinensis* 'Pfitzeriana' was previously reported (3). Annual costs of producing plants in the other four plant groups are reported in companion articles (pages 39-59). Fifth, summaries were made for annual fixed, variable, and total costs for each of the selected species according to size of nursery (Tables 1-4).

## RESULTS AND DISCUSSION

Annual fixed costs associated with capital investment including depreciation, interest, insurance, and taxes were $139,680 per year for the small nursery. In addition, there was $95,025 allocated for general overhead and $7,885 for interest on general overhead, insurance, and taxes, making a total of $242,590 annual fixed costs for the small nursery (Table 1). These costs were divided equally between the five plant groups, with each group receiving an assessment of $48,517 (Table 1). It was felt that the most reasonable way of assigning fixed costs is by area rather than plant. Once the physical facility is provided, fixed costs are incurred at essentially the same amount regardless of how the nursery facility is used. On a per-salable-plant basis, there was a considerable difference in annual fixed costs when they were differentiated by plant group (Table 3). In the small nursery, these were: $1.90 for group I (*Juniperus*), $2.34 for group II (*Cotoneaster*), $2.42 for group III (*Taxus*), $3.00 for group IV (*Viburnum*), and $3.72 for group V (*Rhododendron*). The average over all groups was $2.53. Annual fixed costs for group V were almost double those for group I. These costs were proportionate to the number of salable plants per annum produced in allocated space. Fixed costs as a percentage of total costs ranged from 42% to 51% in the small nursery, averaging 46% across the five groups (Table 3).

For the large nursery, annual fixed costs associated with capital investment, depreciation, interest, insurance, and taxes were $228,526. An additional $150,000 was allocated for general overhead and $12,521 for interest on general overhead, insurance, and taxes, making a total of $391,047 annual fixed costs for the large nursery (Table 2). Assessment per plant group was $78,209 (Table 2). Annual fixed costs per salable plant were: $1.50 for group I, $1.89 for group II, $1.95 for group III, $2.42 for group IV, and $3.00 for group V, averaging $2.04 over all groups (Table 4). Fixed costs as a percent of total costs were lower than for the small nursery, ranging from 37% to 46% and averaging 42% across groups (Table 4). This lower percentage was associated with the lower capital requirement per salable plant capacity.

Annual fixed costs per salable plant were substantially lower for the larger nursery compared to the smaller. For group I the difference was $0.40, for group II $0.45, for group III $0.47, for group IV $0.58, and for group V $0.72, averaging $0.49 across groups. This approximate 25% gain in efficiency when going from the small to the large nursery is once again attributable to the more efficient use of buildings, machinery, and equipment of the large nursery over the small.

Nurserymen having established facilities might well consider annual fixed costs to be lower than those reported here. This is especially true if they compute depreciation and repairs on the original value of land

TABLE 1.--Summary of Annual Fixed, Variable and Total Costs (Dollars) of Operating a Small* Container Nursery in Ohio, 1982

| Item | Group I (Juniper) | Group II (Contoneaster) | Group III (Taxus) | Group IV (Viburnum) | Group V (Rhododendron) | Total |
|---|---|---|---|---|---|---|
| Fixed Cost | | | | | | |
| Land and improvements | 8,616 | 8,616 | 8,616 | 8,616 | 8,616 | 43,080 |
| Buildings | 10,190 | 10,190 | 10,190 | 10,190 | 10,190 | 50,950 |
| Machinery and equipment | 9,129 | 9,129 | 9,129 | 9,129 | 9,129 | 45,645 |
| General overhead | 19,005 | 19,005 | 19,005 | 19,005 | 19,005 | 95,025 |
| Interest on general overhead, insurance, and taxes | 1,577 | 1,577 | 1,577 | 1,577 | 1,577 | 7,885 |
| Subtotal | 48,517 | 48,517 | 48,517 | 48,517 | 48,517 | 242,585 |
| Variable Costs | | | | | | |
| Materials | 45,631 | 38,268 | 45,095 | 30,818 | 33,113 | 192,925 |
| Machinery and equipment | 3,675 | 3,675 | 3,675 | 3,675 | 3,675 | 18,375 |
| Labor | 12,633 | 10,024 | 10,341 | 8,333 | 7,266 | 48,597 |
| Interest on operating capital | 4,641 | 4,040 | 4,425 | 3,207 | 3,447 | 19,760 |
| Subtotal | 66,580 | 56,007 | 63,536 | 46,033 | 47,501 | 279,657 |
| TOTAL | 115,097 | 104,524 | 112,053 | 94,550 | 96,018 | 522,242 |
| Salable Plants per Year | 25,600 | 20,730 | 20,085 | 16,185 | 13,050 | 95,650 |
| Annual Cost per Salable Plant | 4.50 | 5.04 | 5.58 | 5.84 | 7.36 | 5.46 |

*17.04 Acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space

TABLE 2.--Summary of Annual Fixed, Variable and Total Costs (Dollars) of Operating a Large* Container Nursery in Ohio, 1982

| Item | Group I (Juniper) | Group II (Contoneaster) | Group III (Taxus) | Group IV (Viburnum) | Group V (Rhododendron) | Total |
|---|---|---|---|---|---|---|
| Fixed Cost | | | | | | |
| Land and improvements | 16,436 | 16,436 | 16,436 | 16,436 | 16,436 | 82,180 |
| Buildings | 16,127 | 16,127 | 16,127 | 16,127 | 16,127 | 80,635 |
| Machinery and equipment | 13,142 | 13,142 | 13,142 | 13,142 | 13,142 | 65,710 |
| General overhead | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 150,000 |
| Interest on general overhead, insurance, and taxes | 2,504 | 2,504 | 2,504 | 2,405 | 2,504 | 12,520 |
| Subtotal | 78,209 | 78,209 | 78,209 | 78,209 | 78,209 | 391,045 |
| Variable Costs | | | | | | |
| Materials | 92,649 | 76,465 | 90,185 | 61,644 | 66,226 | 387,169 |
| Machinery and equipment | 6,282 | 6,282 | 6,282 | 6,282 | 6,282 | 31,410 |
| Labor | 24,998 | 20,054 | 20,676 | 16,655 | 14,524 | 96,907 |
| Interest on operating capital | 9,285 | 7,995 | 8,776 | 6,334 | 6,812 | 39,202 |
| Subtotal | 133,214 | 110,796 | 125,919 | 90,915 | 93,844 | 554,688 |
| TOTAL | 211,423 | 189,005 | 204,128 | 169,124 | 172,053 | 945,733 |
| Salable Plants per Year | 52,000 | 41,455 | 40,165 | 32,380 | 26,095 | 192,095 |
| Annual Cost per Salable Plant | 4.07 | 4.56 | 5.08 | 5.22 | 6.59 | 4.92 |

*33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space

TABLE 3.--Summary of Annual Fixed, Variable, and Total Costs (Dollars) per Salable Plant of Operating a Small Container Nursery in Ohio, 1982.

| Item | Group I (Juniper) | | Group II (Cotoneaster) | | Group III (Taxus) | | Group IV (Viburnum) | | Group V (Rhododendron) | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost |
| Fixed Cost Items | | | | | | | | | | | | |
| Land and Improvements | .34 | ( 8) | .41 | ( 8) | .43 | ( 8) | .53 | ( 9) | .66 | ( 9) | .45 | ( 8) |
| Buildings | .40 | ( 9) | .49 | (10) | .51 | ( 9) | .63 | (11) | .78 | (11) | .53 | (10) |
| Machinery and Equipment | .36 | ( 8) | .44 | ( 8) | .45 | ( 8) | .56 | ( 9) | .70 | ( 9) | .48 | ( 9) |
| General Overhead | .74 | (16) | .92 | (18) | .95 | (17) | 1.18 | (20) | 1.46 | (20) | .99 | (18) |
| Interest on General Overhead, Insurance, and Taxes | .06 | ( 1) | .08 | ( 2) | .08 | ( 1) | .10 | ( 2) | .12 | ( 2) | .08 | ( 1) |
| Subtotal | 1.90 | (42) | 2.34 | (46) | 2.42 | (43) | 3.00 | (51) | 3.72 | (51) | 2.53 | (46) |
| Variable Cost Items | | | | | | | | | | | | |
| Materials | 1.78 | (40) | 1.85 | (37) | 2.24 | (40) | 1.90 | (33) | 2.54 | (35) | 2.02 | (37) |
| Machinery and Equipment | .15 | ( 3) | .18 | ( 4) | .18 | ( 3) | .23 | ( 4) | .28 | ( 4) | .19 | ( 4) |
| Labor | .49 | (11) | .48 | ( 9) | .52 | (10) | .51 | ( 9) | .56 | ( 7) | .51 | ( 9) |
| Interest on Operating Capital | .18 | ( 4) | .19 | ( 4) | .22 | ( 4) | .20 | ( 3) | .26 | ( 3) | .21 | ( 4) |
| Subtotal | 2.60 | (58) | 2.70 | (54) | 3.16 | (57) | 2.84 | (49) | 3.64 | (49) | 2.93 | (54) |
| Total Annual costs | 4.50 | (100) | 5.04 | (100) | 5.58 | (100) | 5.84 | (100) | 7.36 | (100) | 5.46 | (100) |

*17.04 acres, 340,000 sq ft of growing space , 204,000 sq ft of polyhouse space

improvements, buildings, machinery, and equipment and if they place a low value on their own management input. Good management, for planning purposes, however, dictates computing depreciation and repairs on replacement value rather than cost. It also dictates placing a value on managerial time that would be comparable to salaries paid in competitive firms.

Total variable costs for the small nursery by plant group were $66,580 for group I (*Juniperus*), $56,007 for group II (*Cotoneaster*), $63,536 for group III (*Taxus*), $46,033 for group IV (*Viburnum*), and $47,501 for group V (*Rhododendron*). Total for all groups was $279,657 (Table 1). The difference in total annual variable costs between groups is primarily accounted for by the number of plants in the group. The fewer the plants, the fewer the containers, soil mixture, liners, labor to move containers, etc. On a per-salable-plant basis, the groups practically reversed themselves (Table 3). Annual variable costs by plant were $2.60 for group I, $2.70 for group II, $3.16 for group III, $2.84 for group IV, and $3.64 for group V, averaging $2.93 across groups. In groups with fewer plants, greater costs were incurred on a per plant basis for polyethylene film, chemicals, machinery, equipment, and labor. Other variable costs that varied substantially between groups were the cost of liners and for groups II (*Cotoneaster*) and V (*Rhododendron*) the addition of thermal blankets for overwintering protection. Variable costs for the small nursery ranged from 49% to 58% of total costs, averaging 54% across groups (Table 3).

For the large nursery, variable costs by plant group were $133,214 for group I, $110,796 for group II, $125,919 for group III, $90,915 for group IV, and $93,844 for group V. Total for all groups was $554,688 (Table 2). On a per-salable-plant basis they were $2.57 for group I, $2.67 for group II, $3.13 for group III, $2.80 for group IV, and $3.60 for group V, averaging $2.88 across all groups (Table 4). Variable costs for the large nursery ranged from 54% to 63% of total costs, averaging 58% across all groups.

While fixed cost differentials between size of nursery were substantial, this was not the case with variable costs. The difference for groups I, II, and III was 3 cents and for groups IV and V 4 cents.

Total annual costs are the summation of fixed and variable. For the small nursery they were $115,097 for group I (*Juniperus*), $104,524 for group II (*Cotoneaster*), $112,053 for group III (*Taxus*), $94,550 for group IV (*Viburnum*), and $96,018 for group V (*Rhododendron*). For all groups they totaled $522,242 (Table 1). On a per-salable-plant basis they were $4.50 for group I, $5.04 for group II, $5.58 for group III, $5.84 for group

TABLE 4.--Summary of Annual Fixed, Variable, and Total Costs (Dollars) per Salable Plant of Operating a Large Container Nursery in Ohio, 1982

| Item | Group I (Juniper) | | Group II (Cotoneaster) | | Group III (Taxus) | | Group IV (Viburnum) | | Group V (Rhododendron) | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost | Cost per Saleable Plant | Percent of Total Cost |
| Fixed Cost Items | | | | | | | | | | | | |
| Land and Improvements | .31 | ( 8) | .40 | ( 9) | .41 | ( 8) | .51 | (10) | .63 | (10) | .43 | ( 9) |
| Buildings | .31 | ( 8) | .39 | ( 9) | .40 | ( 8) | .50 | ( 9) | .62 | ( 9) | .42 | ( 9) |
| Machinery and Equipment | .25 | ( 6) | .32 | ( 7) | .33 | ( 6) | .41 | ( 8) | .50 | ( 8) | .34 | ( 7) |
| General Overhead | .58 | (14) | .72 | (16) | .75 | (15) | .92 | (18) | 1.15 | (17) | .78 | (16) |
| Interest on General Overhead, Insurance, and Taxes | .05 | ( 1) | .06 | ( 1) | .06 | ( 1) | .08 | ( 1) | .10 | ( 2) | .07 | ( 1) |
| Subtotal | 1.50 | (37) | 1.89 | (42) | 1.95 | (38) | 2.42 | (46) | 3.00 | (46) | 2.04 | (42) |
| Variable Cost Items | | | | | | | | | | | | |
| Materials | 1.79 | (44) | 1.85 | (41) | 2.24 | (44) | 1.90 | (36) | 2.54 | (39) | 2.01 | (41) |
| Machinery and Equipment | .12 | ( 3) | .15 | ( 3) | .16 | ( 3) | .19 | ( 4) | .24 | ( 3) | .16 | ( 3) |
| Labor | .48 | (12) | .48 | (10) | .51 | (10) | .51 | (10) | .56 | ( 8) | .51 | (10) |
| Interest on Operating Capital | .18 | ( 4) | .19 | ( 4) | .22 | ( 5) | .20 | ( 4) | .26 | ( 4) | .20 | ( 4) |
| Subtotal | 2.57 | (63) | 2.67 | (58) | 3.13 | (62) | 2.80 | (54) | 3.60 | (54) | 2.88 | (58) |
| Total Annual costs | 4.07 | (100) | 4.56 | (100) | 5.08 | (100) | 5.22 | (100) | 6.59 | (100) | 4.92 | (100) |

*33.04 acres, 680,000 sq ft of growing space , 408,000 sq ft of polyhouse space.

IV, and $7.36 for group V, averaging $5.46 across groups (Table 3).

Total annual costs for the large nursery were $211,423 for group I, $189,005 for group II, $204,128 for group III, $169,124 for group IV, and $172,053 for group V. They totaled $945,733 for all groups (Table 2). On a per-salable-plant basis they were $4.07 for group I, $4.56 for group II, $5.08 for group III, $5.22 for group IV, and $6.59 for group V, averaging $4.92 across all groups (Table 4).

Differences in total annual costs per salable plant between the two sized nurseries were $0.43 for group I, $0.48 for group II, $0.50 for group III, $0.62 for group IV, and $0.77 for group V, averaging $0.54 across all groups. It is important to note that of the total differential, all but 3 or 4 cents per group was caused by fixed costs. This means that fixed costs accounted for more than 90% and variable costs less than 10% of the cost differentials per salable plant between the two sized nurseries. For nurseries of the sizes analyzed, economies of size are achieved in fixed rather than variable costs. Variable costs presented should be quite representative for zone six nurseries doing a good job of management.

## SUMMARY

Large sized commercial container nurseries are able to make more efficient use of buildings, equipment, and machinery than small container nurseries. This results in large nurseries having a lower cost per salable plant. Most commercial nurseries are similar in efficiency factors relative to growing space.

Total annual costs per salable plant in the small nursery differentiated by species ranged from $4.50 to $7.36 and averaged $5.46 across species. In the large nursery, comparable values were $4.07, $6.59, and $4.92. More than 90% of the differential noted between the two sized nurseries can be attributed to fixed costs.

Fixed costs per salable plant in the small nursery ranged from $1.90 to $3.72, averaging $2.53. In the large nursery comparable costs were $1.50, $3.00, and $2.04. This approximate 25% gain in efficiency when going from the small to the large nursery is attributable to the more efficient use of buildings, machinery, and equipment of the large nursery over the small. Fixed costs as a percentage of total costs in the small nursery ranged from 42% to 51%, averaging 46% across species. Comparable values for the large nursery were 37%, 46%, and 42%. Differences in fixed costs between plant species were totally determined by space requirements for production.

Variable costs per salable plant showed substantial differences between plant species, but were only slightly affected by size of nursery. In the small nursery they ranged from $2.60 to $3.64, averaging $2.93 across species. Comparable figures for the large nursery were $2.57, $3.60, and $2.88. Major differences between species affecting variable costs were spacing requirements, cost of liners, and overwintering requirements. Variable costs between the two sized nurseries by species ranged from 3 to 4 cents per salable plant. Variable costs as a percentage of total costs in the small nursery ranged from 49% to 58%, averaging 54%. Comparable values for the large nursery were 54%, 63%, and 58%.

These figures demonstrated that variable costs per salable plant, while having wide variations between species, remain reasonably constant when comparisons are made between the two sized nurseries. The small nursery could purchase materials and other variable items almost as cheaply as the large. Fixed costs in contrast changed significantly as size of nursery increased. This occurred because most of the fixed factors required to operate the small nursery, such as management, buildings, and most machinery and equipment, were also adequate to operate the large. As the size of nursery increased, costs for fixed items of production were spread over more salable units, thereby reducing the fixed cost per plant.

## IMPLICATIONS

A comparison of total annual costs of producing plants with prices in Ohio producers' wholesale catalogs would undoubtedly show, in a great many cases, selling prices lower than total annual costs. In fact, if one were to add costs of selling, very few producers would presently be charging enough to cover all costs, let alone profits. How then can producers continue to operate? The answer lies in how producers both experience and figure costs. We have used the economic or accounting method which includes both explicit and implicit costs. Explicit costs are those that are paid directly and easily determined; *e.g.*, cost of liners, soil media, fertilizers, labor, etc. Implicit costs are those that are more difficult to determine such as the cost of equity capital and managerial capacities. The way these costs are determined varies significantly from firm to firm. Well-established nurseries are usually very accurate in determining explicit costs, but often do not consider all implicit costs. They base their costs on "cash flow" and profit and loss on "tax accounting". These established nurseries, having purchased land at low cost, working with depreciated equipment, and often assigning low if any value to their management, would determine their costs at a much lower level than presented in this article. Also, careful site selection could significantly reduce fixed (overhead) costs. However, if one were to start a new container nursery on a "normal" Ohio site, costs would probably be very close to those presented here.

For the industry, selling nursery products for below "accounting costs" implies that well-established nurseries, operating essentially debt free, would have strong staying power, whereas those which have just started or are heavily in debt may not be able to survive, especially if they are relying on their container operation to meet all overhead expenses. Second, starting a container nursery in Ohio would probably not prove profitable unless items like buildings, equipment, machinery, management, etc. could be shared with other enterprises or unless selling prices of nursery products in the zone increased substantially. At current prices, this study shows that the return on investment for new, independently operating, container nurseries in Ohio would be marginal if not negative.

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